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CHAPTER 17

Collection System Rehabilitation

COLLECTION SYSTEM REHABILITATION

17.1 Purpose

This Chapter does not attempt to detail the physical repair of a collection system, but rather presents a philosophy on the overall procedure for effective rehabilitation. The use of this chapter will guide an engineer in developing a program to "catch-up" in the race against infiltration and inflow, and further provide municipalities guidance in the continuous rehabilitation needed to maintain the system.

17.2 Definition

Infiltration - The volume of groundwater entering sewers and building sewer connections from the soil, through defective joints, broken or cracked pipe, improper connections, manhole walls, etc.

Inflow - The volume of any kind of water discharged into sewer lines from such sources as roof leaders, cellar and yard area drains, foundation drains, sump pumps, commercial and industrial "clean water" discharges, drains from springs and swampy areas, etc.

Infiltration/Inflow (I/I) - The volume of both infiltration water and inflow water found in existing sewer systems. Since the two sources are many times indistinguishable, it is impossible to determine the amounts of either.

Continuous Rehabilitation Program - An on-going rehabilitation effort to identify and repair I/I sources and maintain a collection system.

17.3 General

The Division of Water Pollution Control recommends a broad two-tier approach to sewer rehabilitation. First, the municipality should attempt to "catch-up" the collection system maintenance to a degree such as if the maintenance had been performed steadily over the years. Once the system has been thoroughly rehabilitated to an acceptable levelofflow reduction, the municipality shouldthen be prepared to start over again with a program for continuous rehabilitation. The goal of the Continuous Rehabilitation Program is for the system to routinely identify, repair and re-examine their collection system in order to maintain the system in as good condition as possible from now on. The benefit of this approach is to spread the cost of maintenance over the life of the system (by budget) and reduce or slow the rise of the cost per gallon of treatment. Treatment costs are just as high to treat I/I water as they are to treat domestic sewage. Repairing sewage systems and effectively reducing I/I is challenging, difficult and demanding. A successful rehabilitation effort requires both knowledge and persistence. Cities should not wait for grant dollars to begin this effort but should commit resources to begin a program and evolve the program into an effective I/I reduction goal.

17.4 Sub-Basin Approach

Success or failure of a rehabilitation program should not be judged by looking at flows only at the treatment plant. When the flow rate is based on a single point measurement of the system, such as the entrance to the plant, (except for very small collection systems) the increments of reductions are too small to notice for quite some time. The flow is averaged in the overall system as to both infiltration/inflow and flow contributed from sanitary wastes. The one-point plant approach also does not differentiate the intact areas of the system which require no renovation and rehabilitation from the extremely poor areas which would benefit from rehabilitation. The only way to accomplish such a differentiation is to use a sub-basin approach.

Sub-basins are discrete contributing areas of the entire sewer system network which can be isolated and adequately monitored by placing monitoring devices in key manholes. The sub-basin could be an entire drainage area or it could be a small section of a larger drainage basin. The intent of the sub-basin approach is to divide the systems into workable subsections to monitor flow reduction and progress.

The sub-basin also allows rehabilitation costs to be estimated for other similar sub-basins. After repair of the sub-basin, real costs are available in relation to actual flow reduction. This approach is helpful in developing catch-up costs and budget consideration for the cities.

17.5 Sub-Basin Analysis

After dividing the system into sub-basins, each should be analyzed individually, and rehabilitated individually until each basin repair is 100% complete. Do not skip around from basin to basin for points that appear bad. The reason for this is that successful rehabilitation is not usually realized until the last few leaks are repaired. Much work will usually be accomplished with no apparent changes in flow.

One of the causes of this is due to migration. When individual point repairs and joint sealing are performed, infiltration water which once entered the system at the repaired point, migrates along the pipe until another joint or leak is encountered. The water may then enter the pipe, resulting in no flow reduction. For this reason, all points of leakage must be repaired. The old style rehabilitation efforts of repairing leaks of a certain size or leakage rate is useless. Many times, a repair of one large leak will actually allow more water into the system by migration to several small leaks whose total area is greater than the repaired leak.

Basins should be prioritized based upon either visual observations of surcharging, durations and impacts of bypassing, or flow monitoring. If surcharging is present, flow monitors must be of the type to measure velocity at full pipe or the data will be useless. Each sub-basin should follow a three phase repair process as follows in 17.5.1.

17.5.1 Repair Process

Phase I - I/I Source Identification and Location

1. System flow map - sub-basin designations, monitoring points
2. Flow observations and/or monitoring (Base line wet and dry)
3. Line cleaning performed
4. Structural Inspection of manholes
5. Smoke Testing (See Section 17.5.4)
6. TV Inspection (Where needed)
7. Devise a repair work plan
8. Establish budget requirements for Phase II and III
9. Indicate realistic flow reductions anticipated

Phase II - Repair

1. Prepare construction plans

2. Grout, Seal, Replace, Test, etc., as developed from Phase I data for each sub-basin at a time

3. Repair service laterals (see Section 17.5.2)

4. Supervise the work and maintain records

5. Make a "second pass" over the sub-basin locating and repairing remaining I/I sources.

Phase III - Evaluation

1. Monitor wet weather flows, record data

2. Determine I/I reductions

3. Document costs and completed repairs

4. Move to next sub-basin or begin the Continuous Rehabilitation Program

17.5.2 Service Laterals

Working on service laterals cannot be overemphasized. Once the leaks are repaired in the mains, the ground water level in the trench elevates and inundates sections of the laterals. Without repair, the service laterals will leak just as badly as the mains. Using a TV camera during high ground water conditions, crews should attempt to identify leaking laterals. Only the leakers should be inspected further. Most problems are encountered either at the main/lateral junction or within the first six (6) feet off the main. Equipment is available to grout a short section of a service lateral from the main.

17.5.3 Grout and Seal

On grout sealing contracts, the municipality should require the contractor to re-test at least 5% of the joints that were grouted, after the job is complete. If more than one joint between manholes fail, the contractor should pay for the retest and repair. If many roots are present in a line, it is best to dig up and replace the line. Grouting is short-lived where roots are a bad problem. Minor root problems may be treated chemically and then sealed.

Grout selection is very important. Grouts that depend upon the presence of water to maintain their integrity, though cheaper and less toxic to handle, may not be as long lived. If the ground water table drops down below the grade of the sewer long enough for the soil surrounding the sewer line to dry out, these grouts shrink and can leak more than before the grouting was done. The urethane foam grouts are a durable product that will maintain their seal whether water is present or not. The best advice is to talk to a number of manufacturers and weigh the pros and cons on each product.

17.5.4 Smoke Testing

Most leak detection work must be done while it is raining or immediately following a rain. However, smoke testing can be useful during low rainfall seasons for locating roof and area drain connections. Because work is often done at night or under poor working conditions, all manholes should be located and daylighted ahead of time.

Close attention to field procedures is important when conducting a smoke testing program. Each sewer line segment in the sub-basin to be tested should be tested with a blower at both the upstream and downstream manholes. Blowers should be run at full throttle to obtain the best results.

17.5.5 Other Methods of Repair

Depending upon the problems discovered in the Phase I evaluation, other more involved techniques to rehabilitation may be required. These include:

1. Dig up and Replace - Physical replacement of the line.

2. Sliplining - A rigid liner is pushed or pulled through an existing pipe.

3. Inversion Lining - A reaction-based material is turned inside out through an existing pipe.

With the exception of number 1 above, these techniques are performed by companies or contractors experienced in this type of work. Further data is available from the Division of Water Pollution Control, if needed. <u>See Appendix 17-A for presently approved materials for the above methods.</u>

17.6 <u>Continuous Rehabilitation Program</u>

The above techniques apply also to the continuous program. Scheduled monitoring of the system should be performed, along with visual inspections during rainfall events. When problems are encountered, their repair should begin as soon as possible. A budget item is recommended for the program and possibly repair equipment will need to be purchased.

<u>Appendix 17-A</u>

<u>The following materials have been previously approved by the STATE OF TENNESSEE as acceptable for use in the STATE:</u>

<u>1) 9 April 1991 K M Inliner II (also known as Inliner USA)</u>
<u>2) 17 May 1991 U-Liner</u>
<u>3) 6 September 1991 Nu Pipe (folded form of Insituform)</u>
<u>4) Insituform 1987</u>
<u>5) Ultraliner April 1995</u>
<u>6) PipeTec Expanda Pipe April 1995</u>
<u>7) AMLINER April 1995</u>

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CHAPTER 17 TABLE 1
Polyethylene Pipe Size Comparison
for Slip Lining

		Minimum Wall Thickness(inches)					
Inside Diameter of Original Sewer (inches)	Outside Diameter of Liner Pipe (inches)	SDR 26	ID	SDR 21	ID	SDR 17	ID
6	4.500	_------		0.215	4.070	-----	
6	5.375	0.207	4.961	0.256	4.863	0.317	4.741
8	6.625	0.255	6.115	0.316	5.993	0.390	5.845
8	7.125	0.274	6.577	0.340	6.445	0.420	6.285
10	8.625	0.332	7.961	0.411	7.773	0.508	7.609
12	10.75	0.414	9.922	0.512	9.726	0.633	9.484
15	12.75	0.491	11.768	0.607	11.536	0.750	11.250
15	13.38	0.515	12.350	0.638	12.104	0.788	11.804
18	16.00	0.616	14.768	0.762	14.476	0.942	14.116
21	18.00	0.693	16.614	0.858	16.284	1.059	15.882
21	18.70	0.720	17.260	0.891	16.918	1.100	16.500
24	22.00	0.847	20.306	1.048	19.904	1.295	19.410
27	24.00	0.924	22.152	1.143	21.714	1.412	21.176
30	28.00	1.077	25.846	1.334	25.332	1.648	24.704

CHAPTER 17
APPENDIX A
SECTION 02730

MANHOLE REPAIR AND REHABILITATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Section 01530: Barriers

B. Section 01560: Temporary Controls

C. Section 01570: Traffic Regulations

D. Section 01710: Cleaning

E. Section 02610: Paving

F. Section 02722: Sanitary Sewer, Force Main and Appurtenances

1.02 JOB CONDITIONS

A. Immediately notify the Engineer of any unexpected or unusual conditions. Discontinue work until Engineer provides notification to resume work.

B. All work in streets and roadways shall be conducted in strict accordance with provisions of Section 01570.

C. By-pass pumping of sewage will be allowed only as provided in the Project Work Schedule and approved in writing by the Owner.

1.03 QUALITY ASSURANCE

A. Adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for the proper performance of the work specified in this section shall be used.

B. Equipment adequate in size, capacity and numbers to accomplish the work in a timely manner shall be used.

C. Contractor shall provide adequate on-the-job supervision of all work and workmen to assure the work meets all requirements of the Contract.

1.04 SUBMITTALS

A. Contractor shall supply a list of all materials proposed for use under this Section including copies of manufacturers descriptive literature.

B. Submit six (6) copies of the required documents in accordance with Section 01340.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Only materials listed below and/or those approved by the Engineer a minimum of seven (7) calendar days prior to the BID opening will be accepted for use with this project.

B. All materials and supplies shall be prepared, applied and cured in strict accordance with the manufacturers requirements and specifications.

2.02 REPAIR AND REHABILITATION MATERIALS

A. Stopping Leak
1. Foam type grout, “Scotch-Seal 5600”, as manufactured by the 3-M Company**.**
2. DRYCON-OCTOPLUG as manufactured by IPA Systems, Inc.
3. PRECO PLUG as manufactured by FOSROC PRECO Industries, Ltd.

B. Plugging, Smoothing and Filling
1. OCTOCRETE as manufactured by IPA Systems, Ltd.
2. DRYCON-OCTOPLUG as manufactured by IPA Systems, Ltd.
3. PRECO PLUG as manufactured by FOSROC PRECO Industries, Ltd.

C. Coating and Sealing
1. PRECO Waterproofing/Sealer (Gray and White) as manufactured by FOSROC PRECO Industries, Ltd.
2. DRYCON Waterproofing/Sealer (Gray and White) as manufactured by IPA Systems, Inc.

2.03 CLEANING MATERIALS

A. A ”Clean” water for high-pressure washing.

B. Standard Masonry Cleaning Muriatic Acid Solution for chemical cleaning.

2.04 FLEXIBLE JOINT SEALANTS

Flexible joint sealants for setting and sealing top frames to manholes shall be butyl rubber based material conforming to federal specifications SS-S210A, AASHTO M-198, Type B- Butyl Rubber and as follows: maximum of 1% volatile matter and suitable for application temperatures between 10 and 100 degrees F.

PART 3 - EXECUTION

3.01 PREPARATION

A. Remove manhole casting if schedule for repair or replacement, or is loose and requires resetting to seal & pass vacuum test.

B. Inspect manholes before beginning high-pressure wash to identify scope of work, to confirm actual depth for payment purposed, and to confirm rehabilitation category.

C. Clean all interior surfaces by hand and with high-pressure “**clean**” water to remove all loose, deteriorated and/or foreign materials.

D. Wash all interior surfaces with approved solution of Muriatic or hydrochloric acid.

E. Repeat Step C.

F. Chipping smaller cracks and loose material may be necessary to provide proper placement and bonding of plugging materials.

G. Controlled diversion or bypass pumping of the sewage shall be incorporated if required to accomplish a satisfactory reconstruction.

3.02 MAJOR MANHOLE REHABILITATION

A. See “Manhole Rehabilitation Log” in the Project Plans for listing of manhole information and categories.

B. Major Manhole Rehabilitation shall include complete restoration of manholes in fair to poor condition. Manholes in this category shall have a **rating of three**

(3) or greater for “Physical Condition” and ratings of two (2) or four (4)for “Leaking”.

C. Manhole restoration shall consist of:

1. Correct all visible leaks by use of approved hydraulic cement, drilling and pressure grouting (approved grout only) or other approved methods.
2. Repair, reshape or replace invert area.
3. Depressions, holes and very rough areas shall be smoothed with hydraulic cement or thickened mixes of synthetic coating material to provide a surface leveled to a maximum of 1/2 inch roughness.
4. Interior coatings may be applied by “Brushing” or approved “Spraying methods.
5. Coat interior surface with one (1) coat of approved white coating material and allow minimum curing time and proper curing conditions.
6. Apply second (2nd) layer of approved gray coating materials within allowable time to assure proper bond and curing.
7. Allow recommended final curing time and provide recommended curing conditions.
8. Re-set or replace frame and cover as specified.
9. Cast Iron Frames shall be set in a bed of Butyl rubber flexible joint sealant, and secured with anchors as specified and shown in the Project Details.

3.03 MINOR MANHOLE REHABILITATION

A. See “Manhole Rehabilitation Log” in the Project Plans for listing of manhole information and categories.

B. Minor Manhole Rehabilitation shall include complete restoration of manholes in good to moderate condition. Manholes in this category shall have a **rating of two (2) or less for “Physical Condition” and ratings of zero (0), one (1) or three (3) for “Leaking**”.

C. Manhole restoration shall consist of;

1. Correct all visible leaks by use of approved hydraulic cement, drilling and pressure grouting (approved grout only), or other approved methods.
2. Repair, reshape or replace invert area.
3. Depressions, holes and very rough areas shall be filled and smoothed with hydraulic cement or thickened mixes of synthetic coating material to provide a surface leveled to a maximum of 1/2 inch roughness.
4. Interior coatings may be applied by “Brushing” or approved “Spraying” methods.

5. Coat interior surface with one (1) coat of approved white coating material and allow minimum curing time and proper curing conditions.
6. Apply second (2nd) layer of approved gray coating materials within allowable time to assure proper bond and curing.
7. Allow recommended final curing time and provide recommended curing conditions.
8. Re-set or replace frame and cover as specified.
9. Cast Iron Frames shall be set in a bed of Butyl rubber flexible joint sealant, and secured with anchors as specified and shown in the Project Details.

3.04 TESTING

A. Manholes shall be physically, and vacuum or hydrostatically tested to assure compliance with the Specification and workmanship of the finished rehabilitation.

B. Manhole Vacuum Test:

1. All manholes shall be physically inspected, and all visible defects repaired before reinspection.

2. All manholes shall be subjected to a vacuum test of a minimum of ten (10”) inches of mercury (Hg)prior to acceptance by the **OWNER**. The test shall be considered acceptable if the vacuum remains at nine (9”) inches of Hg or higher after the following times:

MANHOLE I. D. (inches)	**48**	**60**	**72**	**84**	**96**	**120**
SECONDS	**60**	**75**	**90**	**105**	**120**	**150**

C. Exfiltration Test

1. Manholes shall be subjected to an exfiltration to a minimum of ten (10) minutes. The test shall be considered a success if the water level in the manhole filled to the lid seat of the frame remains within one (1”) of the starting level for the specified time of ten (10) minutes.
2. The manhole shall be plugged and filled to the test level for a period of fifteen (15) minutes prior to the test to presoak the manhole materials. The water level shall be returned to the specified level before beginning the test.

D. Testing Sequence:

1. All manholes shall be physically inspected and vacuum tested. Manholes failing the test shall be repaired by the **CONTRACTOR,** and retested.

2. Manholes failing the vacuum test two (2) times may, at the discretion of the **OWNER**, be allowed to be hydrostatically tested by an exfiltration test for acceptance.
3. **The OWNER** may require complete replacement of any manhole failing three (3) leak tests. Replacement shall be at no cost to the **OWNER.**

E. The **CONTRACTOR** shall furnish all equipment and personal to conduct the tests in the presence of the **ENGINEER.**

F. Costs for all testing shall be included within and incidental to the Contract Unit Price for manhole repair and rehabilitation.

G. Repairing, retesting, pressure grouting and/or replacement of defective shall be at the sole cost and responsibility of the **CONTRACTOR**, and shall pursued in a timely manner to prevent disruption to the Project and/or sewer services.

H. Manholes moved, displaced and/or damaged in any way during finishing and/or backfilling operation subsequent to successful testing shall be retested for acceptance as specified above, at the sole cost of the **CONTRACTOR.**

END OF SECTION

SECTION 02731

MANHOLE RECONSTRUCTION BY LINING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Section 01530: Barriers

B. Section 01560: Temporary Controls

C. Section 01570: Traffic Regulations

D. Section 01710: Cleaning

E. Section 02610: Paving

F. Section 02722: Sanitary Sewer, Force Main and Appurtenances

1.02 JOB CONDITIONS

A. Immediately notify the Engineer of any unexpected or unusual conditions. Discontinue work until Engineer provides notification to resume work.

B. All work in streets and roadways shall be conducted in strict accordance with provisions of Section 01570.

C. By-pass pumping of sewage will be allowed only as provided in the Project Work Schedule and approved in writing by the Owner.

1.03 QUALITY ASSURANCE

A. Adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for the proper performance of the work specified in this section shall be used.

B. Equipment adequate in size, capacity and numbers to accomplish the work in a timely manner shall be used.

C. Contractor shall provide adequate on-the-job supervision of all work and workmen to assure the work meets all requirements of the Contract.

1.04 SUBMITTALS

A. Contractor shall supply a list of all materials proposed for use under this Section including copies of manufacturers descriptive literature.

B. Calculations:
   1. Contractor shall supply calculation for thickness(es) for each manhole scheduled for reconstruction by lining methods.
   2. Contractor shall secure Engineer's approval prior to beginning work.

C. Submit six (6) copies of the required documents in accordance with Section 01340.

1.05 PATENTS

The Contractor shall warrant and save harmless the Owner and Engineer against all claims for patent infringement and any loss thereof.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Only materials listed below and/or those approved by the Engineer a minimum of seven (7) calendar days prior to the BID opening will be accepted for use with this project.

B. All materials and supplies shall be prepared, applied and cured in strict accordance with the manufacturers requirements and specifications.

2.02 LINING MATERIALS

A. Leak Stopping and Plugging Material - Type "A"

   1. Foam type grout, "Scotch-Seal 5600", as manufactured by the 3-M Company**.**
   2. DRYCON-OCTOPLUG as manufactured by IPA Systems, Inc.
   3. PRECO PLUG as manufactured by FOSROC PRECO Industries, Ltd.

B. Plugging, Smoothing and Filling Materials - Type "B"
   1. OCTOCRETE as manufactured by IPA Systems, Ltd.
   2. DRYCON-OCTOPLUG as manufactured by IPA Systems, Ltd.
   3. PRECO PLUG as manufactured by FOSROC PRECO Industries, Ltd.

C. Coating and Sealing Materials - "C"
   1. MATERIALS: SPRAYWALL URETHANE as distributed and applied by Insituform Corporation.
   2. CHARACTERISTICS: The cured urethane system shall conform to the minimum physical standards, listed as follows:

CURED URETHANE	STANDARD	LONG-TERM DATA(50 YR.)
TENSILE STRESS	ASTM D-638	5,000 psi
FLESURAL STRESS	ASTM D-790	10,000 psi
FLEXURAL MODULUS	ASTM D-790	550,000 psi

2.03 CLEANING MATERIALS

A. A "Clean" water for high-pressure washing.

B. Standard Masonry Cleaning Muriatic Acid Solution for chemical cleaning.

2.04 FLEXIBLE JOINT SEALANTS

Flexible joint sealants for setting and sealing top frames to manholes shall be butyl rubber based material conforming to federal specifications SS-S210A, AASHTO M-198, Type B- Butyl Rubber and as follows: maximum of 1% volatile matter and suitable for application temperatures between 10 and 100 degrees F.

PART 3 - EXECUTION

3.01 PREPARATION

A. Remove manhole casting if schedule for repair or replacement.

B. Inspect manholes before beginning high-pressure wash to identify scope of work, to confirm actual depth for payment purposed, and to confirm rehabilitation category.

C. Clean all interior surfaces by hand and with high-pressure "**clean**" water to remove all loose, deteriorated and/or foreign materials.

D. Wash all interior surfaces with approved solution of Muriatic or hydrochloric acid.

E. Repeat Step C.

F. Chipping smaller cracks and loose material may be necessary to provide proper placement and bonding of plugging materials.

G. Controlled diversion or bypass pumping of the sewage shall be incorporated if required to accomplish a satisfactory reconstruction.

3.02 MAJOR MANHOLE REHABILITATION

A. See "Manhole Rehabilitation Log" in the Project Plans for listing of manhole information and categories.

B. PREPARATION:
1. Leaks and flowing water into the manhole shall be plugged and approved - Type "A" materials and techniques.
2. The manhole invert shall be replaced and/or repaired, and voids, depressions and deep rough areas around pipe entrance and in the manhole walls shall be repaired to provide a leveled surface to maximum of 1/4 inch roughness.

C. LINING APPLICATION:
1. Lining system may be applied to damp, but not wet surfaces.
2. The lining shall be applied by approved appropriate spray techniques to the interior manhole surfaces by trained/experienced technicians.
3. The liner placement shall be in strict accordance with methods approved prior to beginning the work.
4. The finish liner thickness(es) shall be in accordance with the calculated required thickness(es) to a tolerance of minus 0/8 th inches to plus 2/8th inches.
5. Replaced existing or new manhole frame and cover shall be completed prior to placement of the liner to allow the liner to be applied continuously over the frame up to the lid seat.

3.03 CLEAN-UP AND TESTING

A. Physically inspect all manholes and repair all visible defects.

B. Manhole Vacuum Test:
1. All manholes shall be subjected to a vacuum test of a minimum of ten (10") inches of mercury (Hg) prior to acceptance by the **OWNER**. The test shall be considered acceptable if the vacuum remains at nine (9") inches of Hg or higher after the following times:

MANHOLE I. D. (inches)	**48**	**60**	**72**	**84**	**96**	**120**
SECONDS	**60**	**75**	**90**	**105**	**120**	**150**

2. Manholes failing the test shall be repaired and inspected by the Engineer, and then retested. Should the Manhole fail the rest for a total of three (3) failures, the manhole shall be repaired by pressure grouting the exterior and/or removing the previous applied repairs and beginning the reconstruction process again.
3. The CONTRACTOR shall furnish all necessary equipment and personal to conduct the tests in the presence of the ENGINEER.

4. Costs for initial testing shall be included within and incidental to the Contract Unit Price for manhole reconstruction.
5. Repairing. retesting, and/or pressure grouting defective manholes shall be at the sole cost and responsibility of the CONTRACTOR, and shall be pursued in a timely manner to prevent disruption to the Project and/or sewer services.
6. Manholes moved, displaced and/or damaged in any way during the finishing operations subsequent to successful testing shall be retested for acceptance as specified above, at the sole cost of the CONTRACTOR.

END OF SECTION

Appendix 17-B

CITY OF

TION LOG				DATA									PHYSICAL COND.					LEAKING				LOCATION							REHAB. TYPE								CITY		
Old M.H. Number	New M.H. Number	Date Installed	Last Inspected	INV. ELEV.	TOP ELEV.	DIAMETER	WATERTIGHT F & C	C.I.F. & C.	No. INF. PIPE	MAIN MATERIAL	BRICK	PRECAST CONC.	BASE/ INV.	PIPE ENTR.	BARREL	FRAME & COVER	WALLS	BASE/ INV.	PIPE ENTR.	BARREL	FRAME & COVER	HEAVY STREET	CITY STREET	PARKING LOT	DEVELOPED AREA	UNDEVEL. AREA	CREEK/ BANK	BELOW FLOOD	REPLACE	MAJOR REHAB.	MINOR REHAB.	CITY REHAB.	NONE REQD.	RAISE/ W. TGT.	NEW F & C	REMARKS	MAP NO.	PROB. TYPE	SOURCE

PHYSICAL CONDITIONS: (0) NO DEFECTS NOTED, (1) SLIGHT, (2) MODERATE, (3) SEVERE, (4) ROOT INTRUSION

WALLS: (1) SMOOTH, (2) ROUGH / POROUS, (3) VERY ROUGH- OPEN HOLES

NEW MINI SYSTEM__________

OLD MINI SYSTEM________

LEAKING: (0) NO LEAKS NOTED, (1) STREAKING MODERATE, (2) STREAKING SEVERE, (3) VISIBLE MODERATE, (4) VISIBLE SEVERE

MAIN MATERIAL: (1) CLAY, (2) CONCRETE, (3) C.I./D.I., (4) PVC, (5) OTHER

LOGGED BY:

SHEET NO. OF

Date 11-22-94

Appendix 17-C

MH → TV ← MH
FLOW → ←

DATE:________ **TV LOG** LOCATION:____________ CITY OF: ENGINEER:

MINI SYS. OLD	MINI SYS. NEW	TAPE NO.	FROM MH NEW	TO MH NEW	JT.L	PIPE L.	SIZE	P. TYPE	MAP NO.__________________________
									(1) CLAY (2) CONC (3) IRON (4) PVC (5) POLY (6) AC (7) OTHER

TAPE COUNTER NO.____

		MAIN								**SERVICE**				**GEN.**			**MH**		**I/I**		**REHAB.**	**REPLACE**	
STATION	SERVICE POS. (1) L. (2) O, (3) R	COLLAPSED PIPE	BROKEN PIPE	CRACKED PIPE	DETERIORATED PIPE	DROP JT./SHEAR	OFFSET JOINT	DEFECTIVE JOINT	ROOTS AT JOINT (1) L, (2) M, (3) H	LEAKING FROM PIPE	DEFECTIVE TAP	PROTRUDING PIPE	ROOTS IN SERVICE (1) L, (2) M (3) H	SWAG IN PIPE	CAMERA SUMERGED	WILL NOT PASS	LEAKING MH	LEAKING AROUND PIPE	EST.FLOW (GPM)	TV REMARKS	(1) POINT REPAIR (2) GROUT (3) OTHER	(1) REPLACE (2) FORM IN PLACE (3) SLIP LINE (4) OTHER	CORRECTION REMARKS
MH____________																							
1																							
2																							
3																							
4																							
5																							
6																							
7																							
8																							
9																							
0																							
1																							
2																							
3																							
4																							
5																							
6																							
7																							
8																							
9																							
0																							
PAGE ____ OF____	COMMENTS																						

Appendix 17 -D

SMOKE TESTING LOG

DATE:________________ TIME:________________ PROJECT NO:________

LEGEND:
X - MAIN LINE
Y - LATERAL
Z - ROOF LEADER
M - MANHOLE
H - INSIDE HOUSE

1-SLIGHT
2 - MODERATE
3 - HEAVY

LEAK No'S ________
________ ________
________ ________
________ ________
________ ________
________ ________

MINI - SYSTEM: ________ ________
(NEW) (OLD)

BLOWER LOACTION: M. H. ________

REMARKS ________________________________

(SKETCH)

KEY SHEET #:____________________

Date: 11-22-94

Appendix 17-E

LOG

SEWER LINE CLEANING

Map No.______________ Date Cleaned_________ By_____________________
Up Str MH : Old________ New________
Dn Str MH: Old________ New________
Mini-System: Old________ New________
Line Size: inches
Cleaning Summary: Line Material:______________________
Normal_____________ Heavy Roots __________
Heavy Sed._________ Light Roots____________
Large Rx.-Brick______ Mach. Cleaned_________
Grease_____________ Hand Cleaned__________
Broken Pipe________ Other__________________
Remarks: ____

Date 11-22-94

SEWER REHABILITATION PRIORITIES

Priority I

- Point Repair, Replace or Liner - to stop active water flow.
- Lines located in the immediate area of storm sewers or ditches.

Priority II

- Point repair or liner to seal or repair offset joints, root intrusion, broken pipe leaking noted, but no active flow noted.
- Lines located in areas not adjacent to storm sewers or ditches.

Priority III

- Lines that did not exhibit the number and/or severity of problems noted for Priorities I or II at the time of investigation.

Priority IV

- Lines found to be in good condition the time of investigation.

SECTION 02750

SEWER RECONSTRUCTION BY SLIP-LINING METHOD

PART 1 - GENERAL

1.01 REQUIREMENTS

A. Reconstruction of sewer lines by installation of a continuous polyethlene (PE) liner or folded form of polyvinyal chloride (PVC) inserted into an existing sewer.

B. The finished pipe shall be continuous from manhole to manhole and be sealed at the beginning and ending manholes.

1.02 RELATED DOCUMENTS

A. Section 01310: Construction Schedules

B. Section 01340: Shop Drawings, Product Data amd Samples

C. Section 01530: Barriers

D: Section 01560: Temporary Controls

E: Section 01570: Traffic Regulatioons

F. Section 02221: Trenching, Backfill and Compaction

G. Section 02722: Sanitary Sewers, Force Mains and Appurtenances

1..03 SUBMITTALS

A. Submit certified product data for:
1. Polyethlene Pipe
2. Folded Form of PVC
3. Sealing Rope
4. Foam Type Chemical Grout
5. Couplings

6. Service Saddles
7. Silicone Adhesive
8. Rapid Setting Hydraulic Cement

B. Submit six (6) copies of required documents in accordance with Section 01340.

C. Submit six (6) copies of the proposed construction schedules within fourteen (14) calendar days of the Notice toProceed.

D. Submit testing and inspection data as outlined in this Section.

1.04 REFERENCES

A. ASTM 03350

CRITERIA FOR SLOW RATE LAND TREATMENT AND URBAN WATER REUSE

State of Georgia
Department of Natural Resources
Environmental Protection Division
Water Protection Branch
Atlanta, Georgia 30334

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1.0 INTRODUCTION

1.1 PURPOSE

This document is a revision of the February, 1986 Criteria for Slow Rate Land Treatment. This document provides guidelines and criteria for the planning, design, and operation of slow rate land treatment systems in Georgia. The major change in the document from the 1986 version is the inclusion of criteria for urban water reuse systems in Chapter 5. Other changes reflect lessons learned from construction and operation of land application systems in the intervening years. The guidelines and criteria do not apply to overland flow or rapid infiltration.

The term slow rate land treatment as used in this document refers to the advanced treatment of wastewater by irrigation onto land to support vegetative growth. These systems are designed and operated so that there is no direct discharge to surface waters. The irrigated wastewater evaporates and transpires to the atmosphere or enters the groundwater through percolation. Organic constituents in the wastewater are stabilized by soil bacteria. Organic and ammonia nitrogen are taken up by plants, nitrified by soil bacteria, lost to the atmosphere through denitrification, and leached into the groundwater. Phosphorus and other constituents are adsorbed in the soil profile and taken up by plants. Properly designed and operated wastewater irrigation systems produce a percolate water of high quality and thus protect ground and surface water resources.

The term urban water reuse, as used in this document, applies to the use of reclaimed wastewater for the beneficial irrigation of landscaped areas such as golf courses, parks, roadway medians, green areas, etc. Since these areas are designed specifically for public access, the primary concern of urban water reuse, from a regulatory standpoint, is the protection of public health.

The criteria in this document apply primarily to domestic and municipal wastewaters. Wastewater irrigation systems for industrial and animal wastes will be evaluated on an individual basis because treatment requirements for those wastes may differ significantly from those for municipal wastewater.

Finally, this document is not intended to be a cookbook. The design and the operation of wastewater irrigation systems are very site specific. These criteria are intended to provide a guideline for design and operation of slow rate land treatment systems in Georgia. However, hydrogeologic conditions vary widely throughout the State and site assessment and monitoring requirements may vary not only from region to region but even from site to site within the same region.

1.2 SOURCES OF INFORMATION

The Environmental Protection Division recommends the following additional sources of information for the planning, design and operation of slow rate land treatment systems.

1.2.1 Organizations

a. American Society of Agricultural Engineers, 2950 Niles Road, St. Joseph, Michigan 49085.

b. American Society of Agronomy, 667 S. Segoe Road, Madison, Wisconsin 53711.

c. Georgia Agricultural Extension Service, College of Agriculture, University of Georgia, Athens, Georgia 30602.

d. Georgia Irrigation Association, Post Office Box 1829, Tifton, Georgia 31793.

e. The Irrigation Association, 13975 Connecticut Avenue, Silver Spring, Maryland 20906.

f. United States Department of Agriculture (USDA), Soil Conservation Service, Federal Building, Box 13, 335 East Handcock Avenue, Athens, Georgia 30613.

g. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Center, Federal Building, Asheville, North Carolina 28801.

1.2.2 Technical References

a. Brady, N.C. 1974. The Nature and Properties of Soils, Eighth Edition. (ISBN 0-02-313350-3) MacMillan: New York, New York.

b. The Irrigation Association. 1983. Irrigation, Fifth Edition. Silver Spring, Maryland.

c. Metcalf and Eddy, Inc. 1979. Wastewater Engineering: Treatment, Disposal and Reuse. (ISBN 0-07-041667-X) McGraw-Hill: New York, New York.

d. Overcash, M.R. and P. Pal. 1979. Design of Land Treatment Systems for Industrial Wastes - Theory and Practice. Ann Arbor Science: Ann Arbor, Michigan.

e. Reed, S.C. and R.W. Crites. 1984. Handbook of Land Treatment Systems for Industrial and Municipal Wastes. (ISBN 0-8155-0991-X) Noyes Publications: Park Ridge, New Jersey.

f. Rich, L.G. 1980. Low Maintenance, Mechanically Simple Wastewater Treatment Systems. (ISBN 0-07-052252-9) McGraw-Hill: New York, New York.

g. Smedema, L.K. and D.W. Rycroft. 1983. Land Drainage: Planning and Design of Agricultural Drainage Systems. (ISBN 0-8014-1629-9) Cornell University Press: Ithaca, New York.

h. United States Department of Agriculture. National Engineering Handbook, Sections 15 and 16. Soil Conservation Service. Washington, D.C.

i. United States Department of Agriculture. 1985. Georgia Irrigation Guide. Soil Conservation Service. Athens, Georgia.

j. United States Environmental Protection Agency. 1981. Process Design Manual: Land Treatment of Municipal Wastewater. (EPA 625/1-81-013) Center for Environmental Research Information. Cincinnati, Ohio.

k. United States Environmental Protection Agency. 1983. Design Manual: Municipal Wastewater Stabilization Ponds. (EPA-625/1-83-015) Center for Environmental Research Information. Cincinnati, Ohio.

l. Water Pollution Control Federation, American Society of Civil Engineers. 1977. WPCF Manual of Practice No. 8: Wastewater Treatment Plant Design. Washington, D.C.

2.0 PROCEDURES FOR STATE REVIEW AND APPROVAL

2.1 PROPOSAL FOR LAND TREATMENT

The Georgia Water Quality Act and the Georgia Rules and Regulations for Water Quality Control govern procedures necessary to gain State of Georgia approval of slow rate land treatment systems. The steps outlined in Table 2.1-1 are in accordance with the Act and Rules. These steps are explained in the following sections. Projects funded under the State Revolving Loan Fund Program (SRF) (Title VI of the Federal Clean Water Act) must meet certain federal requirements in addition to the steps listed in Table 2.1-1.

2.1.1 Site Inspection and Concurrence

The owner, his engineer or agent must submit to the Division a letter of intent to develop a wastewater irrigation system. The letter should indicate the projected design flow for this system and proposed source(s) of project funding. The letter should also request a site inspection. Accompanying the letter of intent should be a "Site Selection and Evaluation Report." The report must identify potential land treatment sites and provide a preliminary environmental and soil evaluation of selected sites. Table 2.1-2 outlines information generally needed in the Site Selection and Evaluation Report. Additional information may be required as needed.

Upon receipt of the report, an EPD representative will inspect the selected site(s). A preliminary site concurrence or denial letter will be written based on an engineering and geologic evaluation of site conditions. It should be noted that site concurrence is preliminary and pertains only to general wastewater treatment and application to the land. The letter will indicate what requirements are necessary to proceed with the project. Site concurrences for slow rate land treatment are valid for one year. If detailed design has not begun within this period, the EPD may choose to reevaluate the project.

2.2 ENVIRONMENTAL INFORMATION DOCUMENT & DESIGN DEVELOPMENT REPORT

After a site has been selected by the owner and accepted by the EPD as suitable for slow rate land treatment, the owner must complete an "Environmental Information Document" (EID) and prepare a "Design Development Report" (DDR). The EID is to be developed prior to or concurrently with the DDR. The EID shall be a short and concise document that adequately discusses the environmental impact of the proposed project and is not expected to be a complete environmental impact study. The preparer of the document

Table 2.1-1
STEPS FOR GEORGIA ENVIRONMENTAL
PROTECTION DIVISION (EPD) REVIEW AND
APPROVAL OF SLOW RATE LAND TREATMENT SYSTEMS

1.0 Letter of Intent and Site Selection and Evaluation Report submitted to EPD by owner or owner's representative.

- 1.1 EPD conducts site inspection
- 1.2 Site concurrence or denial issued by Division

2.0 Environmental Information Document

- 2.1 Owner holds public meeting
- 2.2 Submitted <u>with</u> DDR and minutes from public meeting

3.0 Design Development Report:

- 3.1 Submitted for EPD review
- 3.2 Geologic Survey reviews site
- 3.3 Accepted by EPD as the basis for facility design
- 3.4 Permit application sent to owner

4.0 Application for permit to apply treated wastewater to land:

- 4.1 Permit application completed and submitted to EPD
- 4.2 Application reviewed and checked against design development report and environmental information document

5.0 Land Application System (LAS) Permit drafted by Division.

- 5.1 Industrial pretreatment requirements included if necessary
- 5.2 Draft permit and monitoring requirements sent to owner for comment
- 5.3 Draft permit modified if necessary

6.0 Public Notice:

- 6.1 Public Notice drafted by EPD
- 6.2 One copy transmitted to owner for advertisement, one copy advertised by Division
- 6.3 Public comment period
- 6.4 Public Notice requirements completed
- 6.5 Trust Indenture executed for privately owned facilities

7.0 Final Land Application System (LAS) Permit issued.

- 7.1 Signed by Division Director

7.2 Sent to facility owner

8.0 Plans and Specifications:

8.1 Submitted for EPD review
8.2 Checked against accepted Design Development Report
8.3 Approved by Division for construction

9.0 Plan of Operation and Management:

9.1 Submitted by owner for EPD review
9.2 Approved by Division
9.3 Incorporated into final LAS Permit

10.0 Certification of Construction Completion:

10.1 Submitted to EPD by design engineer
10.2 EPD conducts facility inspection to verify compliance with approved plans and specifications

11.0 Authorization to commence operation at design flow.

Table 2.1-2
SITE SELECTION AND EVALUATION REPORT
(REQUIRED INFORMATION FOR EACH SITE UNDER CONSIDERATION)

1.0 Site Description:

- 1.1 Location map
- 1.2 Topographic map
- 1.3 Soil survey map
- 1.4 Known cultural or historic resources (cemeteries, archaeologic sites, etc)

2.0 Site Soil Characteristics: [a]

- 2.1 United States Soil Conservation Service soil series classifications
- 2.2 Narrative description for same including:
  - 2.2.1 Texture
  - 2.2.2 Permeability
  - 2.2.3 Slope
  - 2.2.4 Drainage
  - 2.2.5 Depth to seasonal high water table
  - 2.2.6 Depth to bedrock
  - 2.2.7 Erodibility

3.0 100 year flood elevation for site (if applicable).

4.0 Existing vegetative cover.

5.0 Existing land use.

6.0 Present land owner.

---

[a] A detailed soil investigation report is required to be submitted with the Design Development Report (reference Tables 2.2-2 and 2.2-3).

should consider environmental impacts in the areas listed in Table 2.2-1. All areas, of course, may not be pertinent for each project and the degree of detail will vary depending on the project size and location. The DDR should include, but is not limited to, the information outlined in Tables 2.2-2 and 2.2-3.

When the EID and DDR are completed and prior to submitting them for EPD review, the owner must conduct a minimum of one public meeting. The purpose of the meeting is to present to the public the proposed project; its purpose, its design and its environmental impacts. The meeting date and time must be advertised at least 30 days in advance in local newspapers with circulation covering all areas impacted by the project. Provisions to receive written comments should also be made.

Minutes of the public meeting, proof of advertisement, and opinions derived from the meeting must be submitted to EPD with the Environmental Impact Document and the Design Development Report.

2.3 PERMITTING OF SLOW RATE LAND TREATMENT SYSTEMS

The EPD permits all slow rate land treatment systems. This permit incorporates an EPD approved Plan of Operation and Management prepared for the facility by the owner or owner's engineer.

2.3.1 Trust Indenture

Owners of private, domestic wastewater irrigation systems are required to execute a trust indenture with a local government body or other trustee approved by the Division. This trust indenture must guarantee operation and maintenance of the facility in the event of operation or financial default by the owner and must be executed prior to the issuance of the final land application system permit.

2.3.2 Public Notice, Draft and Final Land Application System (LAS) Permits

Upon EPD acceptance of the Design Development Report and Environmental Impact Document, the owner of the proposed facility must submit a written request for a Georgia Land Application System (LAS) Permit. Upon receipt of a completed application for this permit, the EPD will prepare a draft LAS Permit and public notice for the project. One copy of the public notice will be transmitted to the owner for local advertisement and one copy will be published by the Division. The cost of the local advertisement is to be borne by the owner.

A 30 day comment period follows the publication date of each public notice. If no significant adverse public comments are received, a final LAS Permit will be issued for the slow rate land treatment system. The final permit will require

Table 2.2-1
ENVIRONMENTAL INFORMATION DOCUMENT
AREAS OF ENVIRONMENTAL CONSIDERATION

1. Compare with "No Action" Alternative
2. Cultural & Historic Resources
3. Archaeological Resources
4. Flood Plain Management
5. Wetlands Protection
6. Noise
7. Air Quality
8. Water Quality-Surface
9. Groundwater Quality
10. Solid Waste Disposal
11. Coastal Resources
12. Endangered Species
13. Farmland Protection
14. Recreation Potential
15. Wild & Scenic Rivers
16. Demographic Changes
17. Displacement of Individuals
18. Financial Impact to User
19. Conformance to Comprehensive Land Plans and Zoning
20. Erosion and Sedimentation Control
21. Hazards, Nuisances and Site Safety
22. Social and Economic Factors
23. Direct and Indirect Impacts
24. Present and Future Conditions
25. Primary and Secondary Impacts
26. Cumulative Impacts

Table 2.2-2
DESIGN DEVELOPMENT REPORT
REQUIRED INFORMATION

1.0 Site Description:

- 1.1 Location map
- 1.2 Climate
- 1.3 Geology (including subsurface hydrology)
- 1.4 Topography
- 1.5 Access
- 1.6 Water supply wells within 2500 L.F. of facility

2.0 Scaled drawing with 2 foot elevation contours showing the preliminary site layout including:

- 2.1 Preapplication treatment facility
- 2.2 Storage pond(s)
- 2.3 Spray fields
- 2.4 Buffer zones
- 2.5 Hand auger, test pit and soil boring locations
- 2.6 Access roads and utilities
- 2.7 Watercourses
- 2.8 Drainage Structures
- 2.9 Flood elevations
- 2.10 Residences and habitable structures within or adjacent to site

3.0 Design wastewater characteristics (influent to preapplication treatment and treated effluent to spray fields). If the project involves an existing facility, then actual, recent data should be used:

- 3.1 Average and peak daily flows
- 3.2 Biochemical Oxygen Demand [a]
- 3.3 Total Suspended Solids
- 3.4 Ammonia Nitrogen, Total Kjeldahl Nitrogen, Nitrate and Nitrite
- 3.5 Total Phosphorus
- 3.6 Chloride
- 3.7 Sodium Adsorption Ratio [b]
- 3.8 Electrical Conductivity
- 3.9 Metals/Priority Pollutants [c]

4.0 Water Balance/determination of design wastewater loading rates for each sprayfield (if appropriate).

5.0 Nitrogen Balance/selection of cover crop and management scheme.

6.0 Background groundwater samples

7.0 Phosphorus and other constituent loading rates

8.0 Determination of wetted field area(s) and required storage volume.

9.0 Process design for preapplication treatment facility.

- 9.1 Schematic of pump stations and unit processes
- 9.2 Basin volumes, loading rates, hydraulic detention times, etc.
- 9.3 Capacity of pumps, blowers and other mechanical equipment (information for the irrigation pump station must accompany plans and specifications submittal)

10.0 Detailed Soil Investigation Report (reference Table 2.2-3).

---

[a] Chemical Oxygen Demand or Total Organic Carbon may be substituted for industrial wastewaters where appropriate.

[b] Sodium Adsorption Ratio = $\dfrac{Na^{+1}}{SQR\,[(Ca^{+2} + Mg^{+2})/\,2]}$

Where Na^{+1}, Ca^{+2} and Mg^{+2} in the wastewater are expressed in milliequivalents per liter (meq/l) and SQR represents "square root of".

[c] Metal and priority pollutant analysis is required for all industrial wastewaters and municipal wastewater systems that receive industrial process wastes. Analyses required depend on the particular process wastewater being discharged and will be determined on a case-by-case basis. However, in all cases the presence of industrial process wastewaters must be identified.

Table 2.2-3
DETAILED SOIL INVESTIGATION REPORT
REQUIRED INFORMATION

1.0 Site description:

- 1.1 Location map
- 1.2 Topographic map
- 1.3 Soil Survey map
- 1.4 Hand auger, test pit and soil boring locations

2.0 Soil series descriptions (each soil series present).

- 2.1 Texture
- 2.2 Permeability
- 2.3 Slope
- 2.4 Drainage
- 2.5 Depth to seasonal high water table
- 2.6 Depth to bedrock
- 2.7 Erodibility

3.0 Soil characteristics (each soil series present):

3.1 Hand auger, test pit and soil boring logs:

- 3.1.1 Soil horizons
- 3.1.2 Depth to groundwater
- 3.1.3 Depth to rock

3.2 Unified Soil Classification

3.3 Results from saturated hydraulic conductivity testing

3.4 Results from soil chemistry testing:

- 3.4.1 Ph
- 3.4.2 Cation Exchange Capacity
- 3.4.3 Percent Base Saturation
- 3.4.4 Phosphorus Absorption
- 3.4.5 Nutrients (N,P,K)
- 3.4.6 Agronomic trace elements

3.5 Engineering properties of soils proposed for pond construction

- 3.5.1 Clay content

3.5.2 Permeability
3.5.3 Plasticity

4.0 Identification of subsurface conditions adversely affecting vertical or lateral drainage of the land treatment site.

5.0 Delineation of soils and areas suitable and not suitable for wastewater irrigation.

6.0 Determination of design percolation for each soil type.

submission and approval by the EPD of the Plan of Operation and Management for the facility prior to start-up and operation.

2.3.3 Plan of Operation and Management

An outline for the scope of the Plan of Operation and Management required for the Georgia Land Application System Permit is presented in Appendix Section 7.1. The Plan is written by the owner or owner's engineer during construction of the slow rate land treatment system. Once accepted by the Division, this Plan becomes the operating and monitoring conditions for the facility. Therefore, the plan must address wastewater application rates, spray field cycling, monitoring requirements, harvesting schedules, maintenance schedules, and all other information necessary for successful operation. It may be included as a chapter in the facility's Operation and Maintenance Manual.

2.4 ENGINEERING PLANS AND SPECIFICATIONS

2.4.1 Review

After EPD acceptance of the Design Development Report, the owner can submit detailed construction plans and specifications. Pump curves and hydraulic calculations for the distribution system must accompany the plans and specifications. The plans and specifications should be completed in accordance with the rules and current policies of the Division. The plans and specifications will be reviewed for consistency with the Design Development Report and accepted engineering standards. Upon review of the plans and specifications and issuance of the final LAS Permit a letter approving the plans and specifications for construction will be written. This approval is valid for one year. If construction has not begun within this period, the project will require reevaluation.

IMPORTANT: No slow rate land treatment system can be approved for construction until a final LAS Permit for the facility has been issued. Detailed design work undertaken prior to permit issuance is at the owner's risk. Approval for construction of privately owned, domestic wastewater irrigation systems is contingent upon execution of a trust indenture and issuance of the final permit (ref. Sec 2.3.1).

2.4.2 Construction

The Division may choose to make interim inspections of projects under construction to ascertain their progress and adherence to the approved plans and specifications. Upon project completion, the design engineer must certify, in writing, to the Division that the project was constructed in accordance with the approved plans and specifications. Upon receipt of this certification, an EPD representative will inspect the completed facility. When the facility is verified as being complete and operational, a letter authorizing operation under the facility's LAS Permit will be issued. One copy of the as-built drawings must be submitted to EPD.

3.0 GUIDELINES AND CRITERIA FOR DESIGN

3.1 SUITABILITY OF SITES FOR WASTEWATER IRRIGATION

3.1.1 Location

There are two, often contradictory requirements for slow rate land treatment sites; proximity to the wastewater source and a large tract of suitable, undeveloped land. Additional considerations are a moderate degree of isolation, ease of access, availability of utilities and protection from flooding. Wastewater irrigation systems can be developed on agricultural land and in forests. The Georgia Environmental Protection Division (EPD) will also concur with wastewater irrigation of golf courses, cemeteries, green areas and parks. These are considered urban water reuse projects and special preapplication treatment requirements apply to such systems. See Section 5.0.

3.1.2 Topography

Maximum grades for wastewater spray fields are limited to 7 percent for row crops, 15 percent for forage crops and 30 percent in forests. Sloping sites promote lateral subsurface drainage and make ponding and extended saturation of the soil less likely than on level sites. Depressions are to be avoided.

3.1.3 Soils

In general, soils with a USDA Soil Conservation Service permeability classification of moderate to moderately rapid (0.6 to 6.0 inches/hour) are suitable for wastewater irrigation. However, groundwater and drainage conditions must also be suitable. Soils which are poorly drained, have high groundwater tables or restrictive subsurface soil layers are not suitable for slow rate land treatment without drainage improvements.

3.2 SOIL INVESTIGATIONS

3.2.1 General

Soil investigations for land treatment differ greatly from investigations for foundations, roads and other civil engineering works. As a result, different investigative and testing methods are required. The land treatment soil investigation must characterize the permeability, and chemical properties of the first 5 to 10 feet of the soil profile. It must verify Soil Conservation Service soil mapping. It must also determine the elevation of the seasonal high groundwater, establish the groundwater flow direction and gradient, and identify any subsurface conditions which may limit the vertical or lateral drainage of the land treatment site. The number of soil samples necessary to supply all of this information will be dependent on the nature of the particular site. As a minimum however, EPD recommends that at least one sample be taken for every 5 to 10 acres of <u>each soil series</u> to confirm the Soil Conservation Service mapping and to provide a sufficient number of undisturbed soil samples. The specific information required for design is outlined in Table 2.2-2.

3.2.2 Saturated Hydraulic Conductivity Testing

Saturated vertical hydraulic conductivity testing is required for the most limiting horizon of each soil series present. The most limiting soil horizon should be determined from soil survey information. A minimum of three (3) tests for each soil series should be performed. If the proposed site is to be clear cut, the permeability tests must be done following the clear-cutting and establishment of a vegetative cover. Testing for saturated horizontal hydraulic conductivity is additionally required when subsurface drainage systems are planned or when lateral subsurface drainage is the predominant drainage mechanism for the land treatment site.

Acceptable methods for saturated hydraulic conductivity testing are listed in Table 3.2-1. Percolation tests as performed for septic tank drain fields are not acceptable.

3.2.3 Soil Chemical Testing

The pH, Cation Exchange Capacity, and Percent Base Saturation, of each soil series must be determined from samples taken from the A and B horizons. These chemical tests determine the retention of wastewater constituents in the soil and the suitability of the soil for different cover crops. A minimum of three (3) samples for each soil series should be taken. Testing for soil nutrients (nitrogen, phosphorus and potassium) and agronomic trace elements may be included if appropriate for the vegetative management scheme.

Soil chemical testing should be in accordance with the latest edition of Methods of Soil Analysis published by the American Society of Agronomy, Madison, Wisconsin.

Table 3.2-1
HYDRAULIC CONDUCTIVITY TEST METHODS
(Reference Section 6.2)

1.0 SATURATED VERTICAL HYDRAULIC CONDUCTIVITY [a]

1.1 Laboratory Tests: [b]

Constant Head Method (coarse grained soils)	ASTM D 2434-68 AASTHO T 215-70 Bowles (1978), pp 97-104 Kezdi (1980), pp 96-102
Falling Head Method [c] (cohesive soils)	Bowles (1978), pp 105-110 Kezdi (1980), pp 102-108

1.2 Field Tests:

Ring Permeameter Method	Boersma (1965) U.S. EPA (1981), pp 3-22 to 23
Double Tube Method	Bouwer and Rice (1966) U.S. EPA (1981), pp 3-22 to 24
Air-Entry Permeameter Method	Bouwer (1966) Reed and Crites (1984), pp 176 to 180 Topp and Binns (1976) U.S. EPA (1981), pp 3-22 to 27
Constant Head Permeameter	Amoozegar (1989) Soil Sci. Soc. Am. J. 53:1356-1361

2.0 SATURATED HORIZONTAL HYDRAULIC CONDUCTIVITY [d]

2.1 Field Tests:

Auger Hole Method [c]	Reed and Crites (1984), pp 165 to 168 U.S. EPA (1984), pp 3-31 to 35
Slug Test	Bouwer and Rice (1976)

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[a] Other methods, properly documented, may be accepted by the EPD. However, "standard" percolation tests as performed for septic tank drain fields are not acceptable.

b These tests require undisturbed field samples properly prepared to insure saturation. Reconstructed field samples are not acceptable. A description of the field sampling technique should accompany the laboratory testing results.

c Methods recommended by the EPD.

d Testing for saturated horizontal hydraulic conductivity is required at land treatment sites where drainage improvements are planned and where lateral, as opposed to vertical subsurface drainage, is the predominant drainage pathway.

3.3 PREAPPLICATION TREATMENT REQUIREMENTS

3.3.1 General

Wastewater irrigation systems have a demonstrated ability to treat high strength organic wastes to low levels. However, such systems require a high degree of management with particular attention paid to organic loading rates and aeration of the soil profile between wastewater applications.

The EPD requires that all domestic and municipal wastewaters receive biological treatment prior to irrigation. This is necessary to:

a. Protect the health of persons contacting the irrigated wastewater.

b. Reduce the potential for odors in storage and irrigation.

Some industrial wastewaters may be suitable for direct land treatment by irrigation under intensive management schemes. The EPD will evaluate such systems on a case-by-case basis.

3.3.2 BOD and TSS Reduction, and Disinfection

Preapplication treatment standards for domestic and municipal wastewaters prior to storage and/or irrigation are as follows:

a. Restricted Use (No Public Access)

All wastewater must be treated to a 5-day Biochemical Oxygen Demand of 50 mg/l at average design flow and 75 mg/l under peak loads. Total Suspended Solids are limited to 50 mg/l for mechanical systems and 90 mg/l for ponds. Disinfection is generally not required for restricted access land treatment sites. The EPD may, however, require disinfection when deemed necessary.

b. Limited Use (Controlled Public Access)

All wastewater must be treated to a 5-day Biochemical Oxygen Demand of 30 mg/l at average design flow and 50 mg/l under peak loads. Total Suspended Solids are limited to 30 mg/l. Disinfection is generally required.

c. Water Reuse (Unlimited Public Access)

Sites open to public access include golf courses, green areas, parks, and other public or private land not expressly closed to the public. Such projects are considered water reuse systems and requirements are outlined in Section 5.0.

3.3.3 Nitrogen

Maximum nitrogen removal occurs when nitrogen is applied in the ammonia or organic form. Nitrate is not retained by the soil and leaches to the groundwater, especially during periods of dormant plant growth. Therefore, the preapplication treatment system must not produce a nitrified effluent.

The EPD recommends that aerated or facultative wastewater stabilization ponds be used for preapplication treatment where possible. These systems generally produce a poorly nitrified effluent well suited for wastewater irrigation. When mechanical plants are employed for preapplication treatment, they should be designed and operated to limit nitrification.

The Design Development Report should indicate the expected range of nitrogen removal in the preapplication treatment system. Predictive equations for nitrogen removal in facultative wastewater stabilization ponds have been developed by Pano and Middlebrooks (1982), and Reed (1985).

3.3.4 Treatment and Storage Ponds

Two treatment cells followed by a storage pond and irrigation pump station are required for all pond preapplication treatment systems. The treatment cells may be aerated, facultative or a combined aerated/facultative system. They may be separated by earthen dikes or floating baffles. However, the storage pond and irrigation pump station must be hydraulically separate from the treatment cells (i.e. pumping must not affect hydraulic detention time in these cells).

IMPORTANT: If initial flows are going to be significantly below design, EPD recommends that construction be phased. The storage pond should not be built for ultimate flow. Phasing is necessary to avoid erosion, odor, and liner failure problems which can occur in such circumstances.

The United States Environmental Protection Agency's October 1983 Design Manual: Municipal Wastewater Stabilization Ponds is recommended as a reference for design of preapplication treatment ponds.

Ponds used for preapplication treatment must have liners to prevent seepage from exceeding 1/8 inch per day. Either properly constructed clay or synthetic liners may be used. Facultative pond cells should have a length to width ratio of 4:1 (to minimize short circuiting) with a depth of between 3 and 5 feet. Sizing of complete and partially mixed aerated ponds should be based on first-order removal rate kinetic equations and the expected annual temperature variation. A 2 foot freeboard is required for all ponds less than or equal to six acres and a 3 foot freeboard is required for all ponds larger than six acres.

Ponds used for storage of treated wastewater must have liners to prevent seepage from exceeding 1/8 inch per day. Because storage ponds fluctuate greatly in water level, it is extremely difficult to maintain an effective clay liner due to drying, cracking, and erosion. EPD highly recommends synthetic liners for storage ponds. If clay liners are used, synthetic or concrete slope protection must be used on interior slopes from six (6) inches above the maximum operational water level to one (1) foot below the lowest operational water level. An appropriate water level must be maintained at all times in clay lined ponds.

Pond dikes must not exceed 3:1 for internal or external slopes. Any pond with a dike taller than 25 feet or which stores in excess of 100 acre feet at maximum depth must comply with the Safe Dam Regulations of the EPD.

3.4 SOIL AND COVER CROP COMPATIBILITY

Inorganic constituents of effluent from preapplication treatment should be compared with Table 3.4-1 to insure compatibility with land treatment site soils and cover crops.

3.5 PROTECTION OF IRRIGATION EQUIPMENT

Prior to pumping to the spray field distribution system, the wastewater must be screened to remove fibers, coarse solids, oil and grease which might clog distribution pipes or spray nozzles. As a minimum, screens with a nominal diameter equal to the smallest flow opening in the distribution system should be provided. Screening to remove solids greater than one third (1/3) the diameter of the smallest sprinkler nozzle is recommended by some sprinkler manufacturers. The planned method for disposal of the screenings must be provided.

Pressurized, clean water for backwashing screens should be provided. This backwash may be manual or automated. Backwashed screenings should be captured and removed for disposal.

Table 3.4-1
SUGGESTED VALUES FOR INORGANIC CONSTITUENTS
IN WASTEWATER APPLIED TO LAND
(Georgia DNR, 1978; U.S. EPA, 1976 & 1981)

Potential Problem and Constituent	No Problem	Increasing Problem	Severe
pH (std. units)	6.5 - 8.4		< 5.0 > 9.0
Permeability			
Electrical Conductivity (µmho/cm)	> 0.50	< 0.50	< 0.2
Sodium Adsorption Ratio [a]	< 5.0	5.0 - 9.0	> 9.0
Salinity			
Electrical Conductivity (µmho/cm)	< 0.75	0.75 - 3.0	> 3.0
Specific Ion			
Anions:			
Bicarbonate (meq/l)	< 1.5	1.5 - 8.5	> 8.5
(mg/l as $CaCo_3$)	< 150	150 - 850	> 850
Chloride (meq/l)	< 3.0	> 3.0	> 10
(mg/l)	< 100	> 100	> 350
Fluoride (mg/l)	< 1.8		
Cations:			
Ammonia (mg/l as N)	< 5.0	5.0 - 30	> 30
Sodium (meq/l)	< 3.0	> 3.0	> 9.0
(mg/l)	< 70	> 70	

Table 3.4-1 (continued)

Potential Problem and Constituent	No Problem	Increasing Problem	Severe

Specific Ion (cont)

Trace Metals (mg/l):

Aluminum	< 10.0		
Arsenic	< 0.2		
Beryllium	< 0.2		
Boron	< 0.5	0.5 - 2.0	> 2.0
Cadmium	< 0.02		
Chromium	< 0.2		
Cobalt	< 0.1		
Copper	< 0.4		
Iron	< 10.0		
Lead	< 10.0		
Lithium	< 2.5		
Manganese	< 0.4		
Molybdenum	< 0.02		
Nickel	< 0.4		
Selenium	< 0.04		
Zinc	< 4.0		

[a] Sodium Adsorption Ratio = $\dfrac{Na^{+1}}{\text{SQR [} (Ca^{+2} + Mg^{+2}) / 2 \text{]}}$

Where Na^{+1}, Ca^{+2} and Mg^{+2} in the wastewater are expressed in milliequivalents per liter (meq/l) and SQR represents "square root of".

3.6 DETERMINATION OF DESIGN PERCOLATION RATE(S)

3.6.1 General

One of the first steps in the design of a slow rate land treatment system is to develop a "design percolation rate." This value is used in water balance calculations to determine design wastewater loading(s) and thus spray field area requirements. The percolation rate is a function of soil permeability and drainage. Because different soil types may have different limiting percolation rates and because the soil types may vary from field to field, it may be necessary for a system to have different design percolation rates for each field.

3.6.2 Design Values

The most limiting layer, i.e. A, B, or C horizon, of each soil series must be identified. Any subsurface conditions which limit the vertical or lateral drainage of the soil profile must also be identified. Examples of such conditions are shallow bedrock, a high water table, aquitards, and extremely anisotropic soil permeability. Values of saturated vertical hydraulic conductivity from soil testing are used to develop the design percolation rate.

Values of saturated vertical hydraulic conductivity must be modified by an appropriate safety factor to determine design percolation. The safety factor reflects the influence of several elements including: the fact that long periods of
saturation are undesirable, the uncertainty of test values, the drainage characteristics of the land treatment site, the variation of permeability within the soil series, the rooting habits of the vegetation, the soil reaeration factors, and the long-term changes in soil permeability due to wastewater application. The EPD recommends that the design percolation rate at land treatment sites with seasonal high groundwater at depths greater than 5 feet be no more than 10 percent of the mean saturated vertical hydraulic conductivity of the most limiting layer within the first five feet from the surface.

Sites with seasonal high groundwater less than 5 feet from the surface may require drainage improvements before they can be utilized for slow rate land treatment. The design percolation at such sites is a function of the design of the drainage system. A safety factor not exceeding 10 percent should be applied to field measured values of vertical and horizontal hydraulic conductivity used for design of subsurface drainage systems.

3.7 DETERMINATION OF DESIGN WASTEWATER LOADING(S)

3.7.1 General

The design wastewater loading is a function of:

a. Precipitation.

b. Evapotranspiration.

c. Design percolation rate.

d. Nitrogen loading limitations.

e. Other constituent loading limitations.

f. Groundwater and drainage conditions.

g. Average and peak design wastewater flows.

Therefore, developing the design wastewater loading is an iterative process. An initial value is selected from water balance calculations and used to determine wetted field area. This loading is then compared to nitrogen and other constituent loading limitations (reference Section 3.8). If the initial value exceeds these limitations, the design wastewater loading is reduced and the process is repeated. This iterative process is illustrated in Appendix Section 7.4.

The EPD limits design wastewater loadings for non-reuse systems to a maximum of 2.5 inches/week and instantaneous wastewater application rates to 0.25 inches/hour. Requests for higher loadings will be evaluated on a case-by-case basis. The design wastewater loading may be fixed at a constant rate or may vary monthly but it must account for site specific climatic and drainage limitations. Also, because a given site may include several different soil types with significant variation in their permeabilities, it is possible for there to be different application rates for different areas of the site. EPD recommends that when this is the case, the fields be laid out to separate the soils with different permeabilities. However, if this is not done and a field includes more than one soil type, the application rate will be limited to the most restrictive soil permeability.

3.7.2 Water Balance

Maximum allowable monthly wastewater loadings are determined from the following water balance equation:

$$D(\text{allowed}) = (\text{Evap} + \text{Perc}) - \text{Precip} \qquad \text{eq. 3.7.2.}$$

Where,	D(allowed)	=	Maximum allowable hydraulic wastewater loading (in/month). This value cannot exceed 0.36 x no. of days in the month.
	Evap	=	Potential Evapotranspiration (in/month)
	Perc	=	Design percolation rate (in/month); reference Section 3.6
	Precip	=	Design precipitation (in/month)

Example water balance calculations are presented in Appendix Section 7.4.3. From these calculations, critical water balance months (i.e. months with the smallest allowable hydraulic wastewater loading) are identified.

3.7.3 Potential Evapotranspiration

Reliable field data for evapotranspiration are difficult to obtain. Therefore, values for average monthly potential evapotranspiration generated from vegetative, soil and climatological data are used in water balance calculations. A list of evapotranspiration references is presented in Section 6.3. For row and forage cover crops, the EPD recommends use of either the modified Penman or the Blaney-Criddle Method calibrated for local conditions. For forested systems or when data for other methods is not available, the Thornthwaite equation adjusted for sunlight duration and latitude can be used. The Thornthwaite equation and adjustment factors for Georgia are presented in Appendix Section 7.2.

The method used to estimate average monthly potential evapotranspiration for water balance calculations must be referenced in the Design Development Report. In addition, these values must be based on a record of 30 years of historical climatic data.

3.7.4 Five-Year Return Monthly Precipitation

The EPD requires the use of five-year return, monthly precipitation values in water balance calculations. Five-year return values are defined as the 80th percentile value in a 30 year ranked listing of historical monthly precipitation data. This corresponds to:

$$\text{Precip(avg)} + (0.85 \times \text{std.dev.}) \qquad \text{eq. 3.7.4}$$

Where, Precip(avg) = Average monthly precipitation from 30 or more year historic record
std.dev. = Standard deviation for same

The most recent thirty year records of both monthly precipitation and temperature are available for all of Georgia from the National Climatological Center of the National Oceanic and Atmospheric Administration in Asheville, North Carolina. The source of precipitation data used for design must be referenced in the Design Development Report.

3.8 NITROGEN BALANCE/COVER CROP SELECTION AND MANAGEMENT

3.8.1 General

Nitrate concentration in percolate from wastewater irrigation systems must not exceed 10 mg/l. Percolate nitrate concentration is a function of nitrogen loading, cover crop, management of vegetation, and hydraulic loading. The design wastewater loading determined from water balance calculations must be checked against nitrogen loading limitations. If for the selected cover crop and management scheme, the proposed wastewater loading results in estimated percolate nitrate concentrations exceeding 10 mg/l, either the loading must be reduced or a cover crop with a higher nitrogen uptake must be selected.

3.8.2 Nitrogen Balance

Percolate nitrate concentrations are estimated from an annual nitrogen balance based on the average design wastewater loading, proposed cover crop, and cover crop management scheme. Example nitrogen balance calculations are presented in Appendix Section 7.4.4; Tables 7.4-2 and 7.4-3.

In nitrogen balance calculations, all nitrogen not lost to denitrification, ammonia volatilization or plant uptake is assumed to leach into the groundwater as nitrate. For row and forage crop systems, assumed losses to denitrification should not exceed 15 percent of the total nitrogen applied. In forest systems, assumed denitrification losses should not exceed 25 percent. Assumed losses to ammonia volatilization should not exceed 5 percent of the total ammonia applied. Soil storage of nitrogen should be assumed to be zero. The EPD recommends Tables 4-11 and 4-12 of the United States Environmental Protection Agency's October 1981 Process Design Manual: Land Treatment of Municipal Wastewater for guidance in selecting cover crops and their nutrient uptake rates. Those tables are reprinted here as Tables 3.8-1 and 3.8-2 for your convenience. In all cases, the source of the plant nitrogen uptake rate used for design must be referenced in the Design Development Report.

3.8.3 Cover Crop Selection and Management

Row crops may be irrigated with wastewater only when not intended for direct human consumption. Forage crops irrigated with wastewater must be harvested and dried before feeding to livestock. Unmanaged, volunteer vegetation (i.e. weeds) is not an acceptable spray field cover. Disturbed areas in forest systems must be initially grassed and replanted for succession to forest.

Spray field cover crops require management and periodic harvesting to maintain optimum growth conditions assumed in design. Forage crops should be harvested and removed several times annually. Pine forest systems should be harvested at 20 to 25 year intervals. Hardwood forest systems should be harvested at 40 to 60 years. It is recommended that whole tree harvesting be considered to maximize nutrient removal. However, wastewater loadings following the harvesting of forest systems must be reduced until the hydraulic capacity of the site is restored. Spray field area to allow for harvesting and the regeneration cycle must be addressed in design.

While high in nitrogen and phosphorus, domestic and municipal wastewaters are usually deficient in potassium and trace elements needed for vigorous agronomic cover crop growth. High growth rate forage crops such as Alfalfa and Coastal Bermuda will require supplemental nutrient addition to maintain nitrogen uptake rates assumed in design. At least annually the soils should be evaluated by the local extension office to determine if soil supplements are needed. Industrial wastewaters considered for irrigation should be carefully evaluated for their plant nutrient value.

Table 3.8-1 (EPA TABLE 4-11)
NUTRIENT UPTAKE RATES FOR SELECTED CROPS
LB/ACRE•YEAR

UNITED STATES EPA 1981 PROCESS DESIGN MANUAL
LAND TREATMENT OF MUNICIPAL WASTEWATER

Phosphorous	Potassium		Nitrogen
Forage Crops			
Alfalfa[a]	201-482	20-31	156-200
Brome Grass	116-201	36-49	219
Coastal Bermuda Grass	357-602	31-40	201
Kentucky Blue Grass	178-241	40	178
Quack Grass	210-250	27-40	245
Reed Canary Grass	299-401	36-40	281
Ryegrass	178-250	54-76	241-290
Sweet Clover	156	18	89
Tall Fescue	133-290	27	268
Orchard Grass	223-312	18-45	201-281
Field Crops			
Barley	112	13	18
Corn	156-178	18-27	98
Cotton	67-98	13	36
Grain Sorghum	120	13	62
Potatoes	205	18	219-290
Soybeans[a]	223	9-18	27-49
Wheat	143	13	18-40

[a] Legumes will also take nitrogen from the atmosphere.

Table 3.8-2 (EPA TABLE 4-12)
ESTIMATED NET ANNUAL NITROGEN UPTAKE IN THE OVERSTORY AND UNDERSTORY VEGETATION OF FULLY STOCKED AND VIGOROUSLY GROWING FOREST ECOSYSTEMS IN SELECTED REGIONS OF THE UNITED STATES

UNITED STATES EPA 1981 PROCESS DESIGN MANUAL
LAND TREATMENT OF MUNICIPAL WASTEWATER

	Tree Age (Years)	Average Annual Nitrogen Uptake (lb/acre/year)
Eastern Forest		
Mixed Hardwoods	40-60	196
Red Pine	25	98
Old Field With White Spruce Plantation	15	250
Pioneer Succession	5-15	250
Southern Forests		
Mixed Hardwoods	40-60	303
Southern Pine With Understory	20	196[a]
Southern Pine With No Understory	20	286
Lake States Forests		
Mixed Hardwoods	50	98
Hybrid Poplar[b]	5	138
Western Forests		
Hybrid Poplar[b]	4-5	268-357
Douglas-Fir Plantation	15-25	134-223

[a] Principal southern pine included in these estimates is loblolly pine.

[b] Short-term rotation with harvesting at 4-5 years; represents first growth cycle from planted seedlings.

3.9 STORAGE VOLUME

The total storage volume required for wastewater irrigation systems consists of three (3) separate storage components such that:

Total Storage = Operational Storage + Wet Weather and Emergency Storage + Water Balance Storage

eq. 3.9

These separate storage components are described in the Sections that follow.

3.9.1 Operational Storage

Operational storage is a design parameter. For example, many wastewater irrigation systems are designed to apply wastewater 5 days per week and store weekend flows. Facilities which harvest cover crops on a frequent basis may stop irrigation to allow drying of the spray fields. Wastewater storage volume is required during these periods.

3.9.2 Wet Weather and Emergency Storage

Wet weather and emergency storage provides for periods of excess rainfall, saturated soil, and equipment failure when wastewater cannot be applied. The Georgia EPD has minimum requirements for wet weather and emergency storage. These are necessary to insure reliability of the slow rate land treatment system.
The volume provided for wet weather and emergency storage must be the greater of 12 days average design flow volume or

$$\frac{\text{Delta P} \times (30.4 \text{ days/month})}{\text{D(allowed) crit}}$$

eq. 3.9.2

Where,

Delta P	=	20 year variation from 5-year return monthly design precipitation (in) Reference Appendix, Section 7.3
D(allowed) crit	=	Maximum allowable hydraulic loading in most critical water balance month (in/month). Reference Section 3.7.2

3.9.3 Water Balance Storage

Water balance storage is a function of wastewater flow, wetted field area and the wastewater loading rate. Therefore, before the water balance storage volume can be determined, the actual rather than design wastewater loading rate (WLR), in/week, must be calculated. In order to calculate the WLR, the areas necessary to eliminate the operational and the wet weather and emergency storage volumes as well as the area necessary to treat a normal week's flow at the design loading rate must be calculated. Once the WLR has been calculated, the required monthly water balance storage is determined from water balance calculations and the following equation:

$$\text{WBS} = \text{D(potential)} - \text{D(allowed)} \qquad \text{eq. 3.9.3}$$

Where,

WBS	=	Required water balance storage (in/month)
D(potential)	=	Potential wastewater loading (in/month); assumes all influent wastewater is applied to the spray fields
D(allowed)	=	Maximum allowable hydraulic wastewater loading (in/month); Reference eq. 3.7.2

Example calculations of this type are presented in Appendix Section 7.4.7.

3.10 DETERMINATION OF WETTED FIELD AREA

The wetted field area is subdivided into individual spray fields. Effluent is normally applied once per week per field. This allows for aeration and drying of the soil profile. A 3 foot zone of aeration must be reestablished between wastewater applications.

The wetted field area is sized to adequately treat four volumes of water; the storage volumes discussed in 3.9 and seven days of the design average daily flow. In equation form, this relationship is represented as:

$$\text{A(wetted)} = \text{A(ADF)} + \text{A(OP)} + \text{A(WW/E)} + \text{A(WBS)} \qquad \text{eq. 3.10}$$

Where,

A(wetted)	=	required wetted field area (acres)
A(ADF)	=	area (acres) necessary to treat seven days' average daily flows
A(OP)	=	area (acres) necessary to treat the optional storage (ref. Sect. 3.9.1)
A(WW/E)	=	area (acres) necessary to treat the wet weather/emergency storage (ref. Sect. 3.9.2)
A(WBS)	=	area (acres) necessary to treat the water balance storage (ref. Sect. 3.9.3)

The EPD requires that sufficient area be provided so that the operational storage, the wet weather and emergency storage and the water balance storage can be eliminated within a 90 day period. The necessary areas for treating the storage volumes are determined using the WLR corresponding to [D(allowed) crit]. Calculation of each of the area elements is discussed in the following sections.

3.10.1 Area for Average Daily Flow, A(ADF)

The area necessary for distributing the average daily flow is calculated using the following formula:

$$A(ADF) = \frac{7 \text{ days}}{1 \text{ week}} \times ADF\,\frac{\text{gal}}{\text{day}} \times \frac{1 \text{ cf}}{7.48 \text{ gal}} \times \frac{1 \text{ acre}}{43{,}560 \text{ sf}} \times \frac{12 \text{ in}}{1 \text{ ft}} \times \frac{1 \text{ week}}{\text{WLR, in}} \qquad \text{eq. 3.10.1}$$

3.10.2 Area for Operational Storage, A(OP)

Spray field area necessary for treating operational storage associated with a plan of operation which calls for spraying less than seven days per week is already provided in A(ADF). Thus, A(OP) should be calculated only for the other elements of operational storage. As mentioned above, the area is based on the critical month WLR and on eliminating the storage volume within a 90 day period.

$$A(OP) = \text{gal} \times \frac{7 \text{ days}}{90 \text{ days}} \times \frac{1 \text{ cf}}{7.48 \text{ gal}} \times \frac{1 \text{ acre}}{43{,}560 \text{ sf}} \times \frac{12 \text{ in}}{1 \text{ ft}} \times \frac{1 \text{ week}}{\text{WLR, in}} \qquad \text{eq. 3.10.2}$$

3.10.3 Area for Wet Weather and Emergency Storage, A(WW/E)

The wet weather and emergency storage volume is also to be eliminated within a 90 day period. Therefore, the equation for calculating A(WW/E) is the same as 3.10.2 with the wet weather and emergency storage volume substituted for the operational storage volume.

$$A(WW/E) = \text{gal} \times \frac{7 \text{ days}}{90 \text{ days}} \times \frac{1 \text{ cf}}{7.48 \text{ gal}} \times \frac{1 \text{ acre}}{43{,}560 \text{ sf}} \times \frac{12 \text{ in}}{1 \text{ ft}} \times \frac{1 \text{ week}}{\text{WLR, in}} \qquad \text{eq. 3.10.3}$$

3.10.4 Area for Water Balance Storage, A(WBS)

The equation to calculate the area necessary to eliminate the water balance storage within a 90 day period is also similar to 3.10.2 with the water balance storage volume substituted for the operational storage volume:

$$A(WBS) = \text{gal} \times \frac{7 \text{ days}}{90 \text{ days}} \times \frac{1 \text{ cf}}{7.48 \text{ gal}} \times \frac{1 \text{ acre}}{43{,}560 \text{ sf}} \times \frac{12 \text{ in}}{1 \text{ ft}} \times \frac{1 \text{ week}}{\text{WLR, in}} \qquad \text{eq. 3.10.4}$$

Example calculations of the wetted field area requirements are contained in section 7.4.7.

3.11 BUFFER ZONES, PUBLIC ACCESS & PROTECTION OF WATER SUPPLY WELLS

3.11.1 Buffer Zones

Buffer zones are required to protect the public from aerosol sprays. These zones should be maintained in forest, shrubs or other screening vegetation. Rights-of-way can be used as part of the buffer area. However, these rights-of-way must be exclusive with no possibility of development.

The following minimum buffer zones must be provided for all systems other than water reuse projects:

a. A 150 foot buffer must be maintained between the edge of the wetted field area and all property lines.

b. A 300 foot buffer must be maintained between the wetted field area and any habitable structure.

c. A 150 foot buffer must be maintained between the edge of the wetted field area and any internal and external public roads.

d. Internal roads that are closed to public use do not require buffer zones. However, wastewater irrigation on these roads is prohibited.

e. A 100 foot buffer is required between the wetted edge of spray fields and the edge of any perennial lake or stream. A 50 foot buffer is required between spray fields and any channelized, intermittent watercourse. If wastewater irrigation causes an intermittent watercourse to become perennial, the 100 foot buffer requirement will apply.

f. A 150 foot buffer must be maintained between the property line and any part of the preapplication treatment facility and storage pond.

g. A 300 foot buffer must be maintained between any habitable structure and any part of the pretreatment facility and storage pond.

These buffer zone requirements may be increased when deemed necessary by the EPD. Buffer zones for water reuse projects are discussed in Section 5.0.

3.11.2 Public Access

Public access to the spray fields at designated sites should be discouraged by posting signs and maintaining well vegetated buffer zones. Fencing of spray fields in remote areas is usually not required. However, fencing and access road gates should be provided along property lines adjacent to residential and other developed areas. Fencing is required at preapplication treatment facilities, pump stations and holding ponds.

3.11.3 Protection of Water Supply Wells

The potential effect of wastewater irrigation on water supply aquifers is site specific and difficult to predict. Abandoned wells within the treatment site must be identified as well as all public and private water supply wells within 2500 linear feet (L.F.) of the land treatment site. It must be clearly shown (through an evaluation of the depth of the water supply aquifer, its gradient, the condition of the aquitard(s), the condition of existing water supply wells, and their capacity) that the LAS system will not have any effect on those wells. Shallow and poorly constructed wells adjacent to and within the land treatment system will require abandonment and sealing.

3.12 SURFACE DRAINAGE AND RUNOFF CONTROL

Drainage of storm runoff should be considered in design. Spray fields must be protected against flooding, ponding and erosion. Runoff from upgradient areas should be channelized through or around the wastewater irrigation site. However, the collection and channelization of irrigated wastewater must be avoided. Direct application of wastewater to drainage ditches and seasonal watercourses is prohibited.

A properly designed and operated slow rate land treatment system will not produce direct runoff; i.e. all water applied will infiltrate into the soil profile. Sites that experience direct runoff as a result of wastewater irrigation will be required to reduce hydraulic loading rates. Tailwater return systems may be required as a remedial action. Indirect runoff as a result of interflow, changes in slope, and shallow restrictive soil layers can be expected at some slow rate land treatment sites. Indirect runoff is acceptable when it is dispersed over a wide area. However, monitoring of streams affected by such indirect runoff will be required.

3.13 SUBSURFACE DRAINAGE

Sites with a seasonal high water table less than 5 feet from the surface will not be accepted for slow rate land treatment unless drainage improvements are made. A 3 foot zone of aeration between wastewater applications is generally desirable.

The EPD recommends Section 16 of the USDA Soil Conservation Service National Engineering Handbook and the 1983 publication Land Drainage by Smedema and Rycroft as references for the design of drainage systems. In addition, the Soil Conservation Service in Athens, Georgia has available the DRAINMOD computer program (Skaggs, 1980; Skaggs and Nassehzadeh-Tabrizi, 1982). This is a comprehensive drainage design model for agricultural and wastewater irrigation systems.

3.14 DISTRIBUTION SYSTEMS AND CONSTRUCTION

3.14.1 General

The EPD recommends Section 15 of the USDA Soil Conservation Service National Engineering Handbook and the 1983 publication Irrigation by the Irrigation Association as references for the design of slow rate wastewater distribution systems. Also recommended are material and installation standards of the American Society of Agricultural Engineers and the Georgia Irrigation Association. Note that these publications were written for the design of supplemental irrigation systems. Therefore not all material contained in these publications will be appropriate for systems intended to treat wastewater through spray irrigation.

Hydraulic calculations for the pump and distribution system must be submitted with the plans and specifications. Spray field pressure variation due to friction loss and static head for solid set, uniformly spaced systems should not exceed plus or minus 10 percent of the design spray nozzle pressure. If this criterion cannot be met, sprinkler head spacing and spray nozzle diameters must be adjusted to insure a uniform application depth. The use of pressure reducing or throttling valves to balance the distribution system should be avoided.

IMPORTANT: The spray fields must be laid out so that the irrigation lines follow the contours of the site. The engineer must visit the site when the contractor is laying the lines out to verify that the lines do follow the contours and that the 50 foot buffer is maintained from intermittent streams including drainage ways which may not have been apparent from the topographical map(s) used to design the system.

Secondary mist nozzles on impact sprinklers should not be used. These saturate the ground around the sprinkler riser and undermine the riser's support. They also make it impossible to inspect operating sprinklers without getting wet.

PVC risers must not be used. The Division recommends that flexible connections be used to connect the risers to the distribution line.

3.14.2 Access, Flow Measurement, and Controls

The layout of spray fields and spray field roads should provide easy access for inspection and maintenance of the distribution system. Control valves should be installed so that they are readily accessible for maintenance and replacement (i.e. either above ground or in a valve pit). In addition to control valves for each field, EPD highly recommends that a shut-off valve be installed for each lateral and each sprinkler. Experience has shown that such valves will expedite maintenance of the system. Taps located near the most distant sprinklers must be provided in each field so pressure gauges can be easily used to verify operating pressures and to locate pressure losses. Spray field access roads must be designed for all weather use. Steep grades should be avoided. Irrigation on access roads is prohibited.

A flow totalizing recorder is required on the discharge of each irrigation pump station to measure the volume of wastewater applied to the spray fields.

A low pressure detection system (with sensors in each field for large systems) must be provided to automatically shut down irrigation pumps in the event of force main, submain, or lateral blowout. Similarly, a high pressure shut-off at the irrigation pumps must be provided. In conjunction with these systems there must be an indicator light which alerts the operator of an early pump shutdown. Depending on the operational control system for the spray fields, automatic shut-off controls for high intensity rainfall and/or high wind speeds may be required.

3.14.3 Freeze Protection

The EPD requires that above ground piping systems should drain when depressurized. Pipe drains should discharge either to the spray fields or to the storage pond(s) and must not produce a runoff.

3.14.4 Construction Disturbance, System Start-up and Testing

Construction activities associated with distribution systems can greatly alter the infiltration rate of spray field soils. Construction disturbance within spray fields must be kept to an absolute minimum. Excessive compaction of surface soils by construction equipment must be avoided. Where land clearing is a part of the construction, final permeability testing must be performed and the permeability must not change more than 15%.

Regrading of pipeline trenches must match original contours. Subsidence of trench backfill must be repaired, as this promotes channelization of runoff and erosion. Cuts or benches on slopes are not permissible. These disturbances intercept shallow, subsurface flow also promoting channelized runoff and erosion.

In forested systems, it is necessary to grub only the pipe centerline. Excessive clearing and grubbing should be avoided. Clearing for above ground piping systems should involve only vegetation that will interfere with operation of the system. All areas disturbed by construction must be revegetated immediately. Areas in which seedlings are to be planted must have a cover crop of grass provided during the first three years following planting of the seedlings.

IMPORTANT: Before seeding or sprigging grass or ground cover in all areas of fields disturbed by construction, the land must be plowed to a depth of 16 inches with chisel plows.

Sloped areas may require protection from erosion. The Manual for Erosion and Sediment Control in Georgia published by the State Soil and Water Conservation Committee of Georgia should be used as a guide for erosion and sediment control during construction of slow rate land treatment systems.

Pressure testing of the irrigation force mains and laterals should be conducted during installation to avoid damage to spray fields from re-excavation and repair. Extensive flushing is usually necessary to clear distribution system pipes of materials which will clog sprinkler nozzles. Care should be exercised to prevent erosion or flooding of the spray fields during pipeline flushing. Every effort should be made to keep trash and debris out of the distribution system. Sprinklers and drain valves should be checked for proper operation prior to installation.

Bare soil resulting from construction can tolerate only short periods of wastewater application before producing runoff. Irrigation of bare soil compacts the soil surface, reduces the infiltration rate, promotes erosion, and hinders the establishment of vegetation. In addition, the treatment capacity of bare soil is poor. Wastewater irrigation on bare soil is not allowed beyond what is necessary to establish a vegetative cover. Wastewater application at the design rate can begin only when a uniform vegetative cover has been established. Specifications for spray field construction must include a revegetation performance standard and this standard must be enforced.

The EPD recommends that spray fields be developed before preapplication treatment facilities are constructed. This allows time for a vegetative cover to be reestablished on construction disturbed areas. Potable, ground or surface water should be used for distribution system testing and irrigation to establish vegetation. Since one to three growing seasons may be required before newly constructed spray fields can accept the design wastewater loading, this start-up period must be considered in the design and operation of slow rate land treatment systems.

4.0 GUIDELINES AND CRITERIA FOR SITE MANAGEMENT

4.1 OPERATION AND MANAGEMENT OF SLOW RATE LAND TREATMENT SYSTEMS

As discussed in Section 2.3, the Georgia Land Application System (LAS) Permit incorporates a Plan of Operation and Management written by the owner or owner's engineer. This plan covers operation of both the spray fields and preapplication treatment facility. It provides a management scheme consistent with the basis of design outlined in the Design Development Report. Once accepted by the EPD, the Plan of Operation and Management becomes the operating and monitoring guidebook for the slow rate land treatment system. An outline for the scope of the Plan of Operation and Management is presented in Appendix Section 7.1.

4.2 MONITORING REQUIREMENTS

4.2.1 General

There are two objectives for a monitoring program at a land application site. The first is to satisfy the permit requirements set by the EPD. The second objective is to provide the data necessary to optimize the system's operation. The data to meet the second objective may or may not be the same as that required by the permit. The facility's Plan of Operation and Management should address the data needs for optimum plant operation.

The sampling and analysis methods used for wastewater and groundwater must be in accordance with the latest edition of Standard Methods for Examination of Water and Wastewater published jointly by the American Public Health Association, the American Water Works Association and the Water Pollution Control Federation, and Methods for Chemical Analysis of Water and Wastes published by the United States Environmental Protection Agency. Soil chemical testing should be in accordance with the latest edition of Methods of Soil Analysis published by the American Society of Agronomy.

4.2.2 Preapplication Treatment Facility and Storage Pond(s)

Influent to the preapplication treatment system and treated effluent applied to the spray fields must be monitored. Parameters which may require monitoring under the system's permit include: influent flow, volume of water applied to the spray fields, BOD (influent & effluent), suspended solids (influent & effluent), fecal coliform bacteria, pH (influent & effluent), ammonia nitrogen, nitrate nitrogen, total Kjeldahl nitrogen, total phosphorus, chloride, Na, K, Ca, Mg, metals, and priority pollutants. The parameters included in the permit monitoring requirements and the sampling frequency for those parameters will be determined on a case by case basis and will be dependent on site conditions.

4.2.3 Groundwater

A system is required for monitoring the quality of groundwater influenced by the slow rate land treatment system. Groundwater leaving the spray site boundaries must meet drinking water standards.

Subsurface geology and the direction of groundwater flow determine the placement and depth of monitoring wells. Minimum monitoring well requirements are as follows:

a. One well upgradient or otherwise outside the influence of the land treatment site for background monitoring.

b. One well within the wetted field area of each drainage basin intersected by the land treatment site.

c. Two wells downgradient of the wetted field area in each drainage basin intersected by the land treatment site.

d. All monitoring wells must extend to sufficient depth to sample seasonal fluctuations of the unconfined water table. Monitoring wells failing to access water within 20 feet of the surface may require deepening or replacement.

e. Monitoring wells must be provided with casings and screens. The casing must be backfilled and sealed to prevent the entry of surface water. This seal should include a concrete apron surrounding the well at the surface. Care should be taken to avoid contamination of monitoring wells both during and after construction.

f. IMPORTANT: Monitoring wells must be numbered and locked.

The EPD requires construction to conform with the Manual for Groundwater Monitoring (May, 1987) which was developed as a reference for the design and construction of groundwater monitoring wells at slow rate land treatment systems (see Figure 4.2-1).

Monitoring of the groundwater under the LAS permit may require measurement of one or more of the following parameters: depth to groundwater, pH, nitrate nitrogen, total phosphorus, electrical conductivity, chloride, fecal coliform bacteria, metals and priority pollutants. The parameters included in the permit monitoring requirements and the sampling frequency for those parameters will be determined on a case by case basis and will be dependent on site conditions. The EPD also encourages the installation and monitoring of soil water lysimeters within the wetted field area. These are useful as trend monitoring devices to identify problems before the groundwater system is affected.

4.2.4 Surface Water and Drainage Systems

When a perennial stream traverses or lies at the boundary of a slow rate land treatment site, water quality monitoring of this stream will be required. The parameters and frequency of monitoring will be specified as a special condition in the facility's LAS Permit. Sampling upstream and downstream of the wetted field area as well as flow measurement may be required.

Land treatment systems incorporating drainage improvements that result in a point discharge to surface waters may be issued a National Pollutant Discharge Elimination System (NPDES) Permit. In addition to requiring a Plan of Operation and Management, the NPDES Permit will include effluent limits, monitoring parameters, and sampling frequencies for the drainage system. The intent of this monitoring is to insure complete renovation of the irrigated wastewater before discharge.

4.2.5 Soil

Representative soil samples from each major soil series within the wetted field area must be taken and analyzed according to the schedule in Table 4.2-1. Soil pH is an indicator of changes in soil chemistry. If soil pH remains constant, analysis of cation exchange capacity and percent base saturation is not required. If the soil pH changes by one unit, analysis of these parameters may be required.

Wastewater irrigation systems receiving industrial process wastes may be required to monitor metals and priority pollutants in site soils and possibly vegetation. The parameters and frequencies will be determined on a case-by-case basis.

Table 4.2-1
SOIL MONITORING REQUIREMENTS

Parameter [a]	Sampling Frequency
pH	1/year
Cation Exchange Capacity	If pH changes
Percent Base Saturation	If pH changes
Phosphorus Adsorption [b]	1/4-years
Metals and Priority Pollutants [c]	1/year

a Composite soil samples representing <u>each</u> soil series within spray fields. Soil samples should be taken at 15 to 30 inches depth. A minimum of one sample for every 10 to 20 acres of each soil series is required.

b At sites receiving high phosphorus loadings where percolate is likely to flow to a sensitive surface water. Sampling frequencies will be determined on a case-by-case basis. At a minimum, sampling is required once every four years.

c Facilities receiving industrial process wastes. Analyses required and sampling frequencies will be determined on a case-by-case basis. At minimum, this sampling is required annually.

4.2.6 Rainfall and Climatic Data

Monitoring of daily rainfall at the land application site is required. Antecedent precipitation and soil moisture conditions can be correlated to provide an operating scheme for the wastewater irrigation system. Monitoring of wind speed and direction may also be required.

5.0 DESIGN GUIDELINES FOR URBAN WATER REUSE

5.1 INTRODUCTION

Urban water reuse is a term generally applied to the use of reclaimed water for the beneficial irrigation of areas that are intended to be accessible to the public, such as golf courses, residential and commercial landscaping, parks, athletic fields, cemeteries and roadway medians. Reclaimed water may also be used for fire protection and aesthetic purposes (landscape impoundments and fountains). Since these areas are designated for public access, protection of public health is the primary concern.

Section 2.0, "Procedures for State Review and Approval," generally applies for all water reuse projects. Since all water reuse systems are different, early contact with EPD is advised.

5.2 WASTEWATER TREATMENT AND DISINFECTION

5.2.1 General

Prior to urban reuse, the reclaimed wastewater must meet advanced treatment limits with a high level of disinfection.

5.2.2 Advanced Treatment

The treatment system shall include the following processes:

- Biological Oxidation/Clarification
- Coagulation/Filtration
- Disinfection

5.2.3 Treatment Criteria

5.2.3.1 Process Control

- Turbidity $\leq$ 3 TU

5.2.3.2 Treatment Criteria

- Total Suspended Solids (TSS) $\leq$ 5 mg/l
- Fecal Coliform $\leq$ 23 per 100 ml
- pH 6-9

5.3 MONITORING REQUIREMENTS

Turbidity shall be monitored continuously on the filtered water prior to disinfection for process control. Turbidity shall not exceed an average of 3 turbidity units. Reclaimed water exceeding 5 TU is to be considered reject water.

TSS and fecal coliform limits shall be monitored after disinfection and reported for permit compliance. The frequency of sampling for these parameters shall be determined at the time of permitting.

Fecal coliform organisms in the reclaimed water shall not exceed 23 per 100 ml, as determined from the geometric mean of bacteriological test results of the last 7 analyses which have been completed. The number shall not exceed 200 per 100 ml in any two consecutive samples.

The need to monitor groundwater and surface waters will be determined on a case-by-case basis at the time of permitting.

5.4 REJECT WATER STORAGE

Reclaimed water must meet the required treatment criteria before it is transported to the reuse area. Because of the need for continuous monitoring of water quality, turbidity monitoring prior to disinfection is required. If for any reason the turbidity limit is not met, the water must be rejected. An off-line system for storage of reject water shall be provided. At a minimum the capacity of this storage shall be equal to 3 days of flow at the average daily design flow of the treatment facility. Provisions for returning this reject water to the facility for further treatment shall be incorporated into the design.

5.5 SYSTEM RELIABILITY REQUIREMENTS

5.5.1 Biological oxidation

- Equalization (for systems which have widely varying flows)
- Standby aeration equipment
- Accessible aeration equipment

5.5.2 Clarification

- Multiple units

5.5.3 Coagulation/Filtration

- Chemical feed facilities for coagulant, coagulant aids, and polyelectrolytes shall be provided. Such chemical feed facilities may be idle if turbidity limits are achieved without chemical addition.
- Multiple, multimedia filter units

5.5.4 Disinfection

- Automatic switchover feed system
- Standby disinfection source
- Consider multiple points of disinfection (before and after storage, prior to long transport lines, etc.)

If ultraviolet light disinfection is used, multiple units must be provided.

5.5.5 Power Supply

- Onsite standby power source/separate feed line
- Automatic switchover

5.5.6 Alarms

Alarms shall be installed to provide warning of:

- Loss of normal power supply
- Failure of pumping systems
- Failure of disinfection system
- Failure to meet turbidity limits

5.6 OPERATION REQUIREMENTS

Operation of reclaimed water systems must follow one of the following options:

(1) The facility's chief operator and operator supervisor shall be class I. On site operation by a class II or higher operator 24 hours per day, 7 days per week.

(2) The facility's chief operator and operator supervisor shall be a class I. On site operation by a class II or higher operator for a minimum of 6 hours per day, 7 days per week in conjunction with one or more of the following:

a) Automatic diversion of reclaimed water that does not meet the turbidity criteria (reject water) to the reject water storage facility.

b) Transport of acceptable reclaimed water to the reuse areas only during periods of operator presence.

5.7 STORAGE OF RECLAIMED WATER

Reclaimed water that meets the required treatment criteria is considered to have met permit and can be transported to a variety of reuse areas. It is anticipated that storage at the plant site or the reuse site will be provided. Unlike land treatment systems utilizing dedicated irrigation sites, the determination of storage capacity will depend on the actual needs of the reuse area. Storage requirements will vary significantly with how the reclaimed water is utilized. Designers must use information from experienced landscapers and water use data from existing and similar applications to determine the operational storage needs of the system. The basis for the storage design must be provided in the Design Development Report. It is expected that in Georgia all reuse systems will require some operational storage for wet weather and growing season needs. The basis for design must be provided in the DDR.

5.8 LIMITED WET WEATHER DISCHARGE

While the demand for reclaimed water normally declines during wet weather periods, the flow in the surface water streams normally increases. For these reasons, the Division may allow limited wet weather discharge of the highly treated wastewater to surface streams in order to facilitate the implementation of reuse projects. If a wet weather discharge will be requested in conjunction with a reuse project, the owner should notify the Division during the initial planning phase and should provide the following information in the Site Selection and Evaluation Report:

- A map showing the proposed receiving stream and the proposed point of discharge.
- Descriptions and locations of sensitive downstream waters such as lakes, drinking water intakes, recreation, drinking water, or trout stream classifications.
- An analysis of historic records for daily rainfall for a period covering at least the past 20 years, using climatic data that are available from, or representative of, the area involved.
- An analysis of the historic records for steam flow in the proposed receiving stream. Because this information is oftentimes not available, it may be necessary for the owner to contact the USGS to obtain flow estimates based on records of nearby/similar streams.
- A preliminary analysis of the proposed operation of the reuse, storage, and limited wet weather discharge systems including identification of the periods of time when a discharge would be necessary and the flows that would be discharged.

The Division will determine if a limited wet weather discharge is feasible and what discharge quantities and stream dilution factors are appropriate.

5.9 ACCESS CONTROL AND WARNING SIGNS

Buffer zones are not generally required for water reuse systems. EPD, however, will evaluate the need for buffer zones on a case-by-case basis.

Within 100 ft. from outdoor public eating, drinking and bathing facilities, low trajectory nozzles, or other means to minimize aerosol formation shall be used.

The public shall be notified of the use of reclaimed water. This shall be accomplished by the posting of advisory signs in areas where reuse is practiced, notes on golf course scorecards, or by other methods. Advisories should be written in positive manner emphasizing the water conservation importance of water reclamation.

5.10 POTABLE WATER CROSS-CONNECTIONS

No cross-connections to potable water systems shall be allowed.

5.10.1 Separation

Maximum obtainable separation of reclaimed water lines and domestic water lines shall be practiced. A minimum horizontal separation of three feet (outside to outside) shall be maintained between reclaimed water lines and either potable water mains or sewage collection lines. Back-flow prevention devices shall be installed on all potable water source connections entering properties served by reclaimed water.

5.10.2 Tagging

All reclaimed water valves and outlets shall be appropriately tagged or labeled to warn public and employees that the water is not intended for drinking. All piping, pipelines, valves, fire hydrants, and outlets shall be color coded to differentiate reclaimed water from potable water. Where hose bibs are present on potable water supply lines and on reclaimed water lines, different sizes shall be established to preclude interchange of hoses.

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7.0 APPENDICES

7.1 PLAN OF OPERATION AND MANAGEMENT FOR SLOW RATE LAND TREATMENT SYSTEMS

This plan should include but not be limited to the following:

7.1.1 Introduction

A. System Description:

1. A narrative description and process design summary for the land treatment facility including the design wastewater flow, design wastewater characteristics, preapplication treatment system and spray fields.

2. A map of the land treatment facility showing the preapplication treatment system, storage pond(s), spray fields, buffer zones, roads, streams, drainage system discharges, monitoring wells, etc.

3. A map of interceptor sewers, force mains and major pump stations tributary to the land treatment facility. Indicate their size and capacity.

4. A schematic and plan of the preapplication treatment system and storage pond(s) identifying all pumps, valves and process control points.

5. A schematic and plan of the irrigation distribution system identifying all pumps, valves, gauges, sprinklers, etc.

B. Discuss the design life of the facility and factors that may shorten its useful life. Include procedures or precautions which will compensate for these limitations.

C. A copy of facility's Georgia Land Application System (LAS) Permit.

D. A copy of facility's National Pollutant Discharge Elimination System (NPDES) Permit, if applicable.

7.1.2 Management and Staffing

A. Discuss management's responsibilities and duties.

B. Discuss staffing requirements and duties:

1. Describe the various job titles, number of positions, qualifications, experience, training, etc.

2. Define the work hours, duties and responsibilities of each staff member.

7.1.3 Facility Operation and Management

A. Preapplication Treatment System:

1. Describe how the system is to be operated.

2. Discuss process control.

3. Discuss maintenance schedules and procedures.

B. Irrigation System Management:

1. Wastewater Application. Discuss how the following will be monitored and controlled. Include rate and loading limits.

   a. Wastewater loading rate (inches/week)
   b. Wastewater application rate (inches/hour)
   c. Spray field application cycles
   d. Organic, nitrogen and phosphorus loadings (lbs/acre per month, etc.)

2. Discuss how the system is to be operated and maintained.

   a. Storage pond(s)
   b. Irrigation pump station(s)
   c. Spray field force main(s) and laterals

3. Discuss start-up and shut-down procedures.

4. Discuss system maintenance.

   a. Equipment inspection schedules
   b. Equipment maintenance schedules

5. Discuss operating procedures for adverse conditions.

   a. Wet weather
   b. Freezing weather
   c. Saturated soil
   d. Excessive winds
   e. Electrical and mechanical malfunctions

6. Provide troubleshooting procedures for common or expected problems.

7. Discuss the operation and maintenance of back-up, stand-by and support equipment.

C. Vegetation Management:

1. Discuss how the selected cover crop is to be established, monitored and maintained.

2. Discuss cover crop cultivation procedures, harvesting schedules and uses.

3. Discuss buffer zone vegetative cover and its maintenance.

D. Drainage System (if applicable):

1. Discuss operation and maintenance of surface drainage and runoff control structures.

2. Discuss operation and maintenance of subsurface drainage systems.

7.1.4 Monitoring Program (reference Section 4.2)

A. Discuss sampling procedures, frequency, location and parameters for:

1. Preapplication treatment system.

2. Irrigation System:

a. Storage pond(s)
b. Groundwater monitoring wells
c. Drainage system discharges (if applicable)
d. Surface water (if applicable)

B. Discuss soil sampling and testing.

C. Discuss ambient conditions monitoring:

1. Rainfall.

2. Wind speed.

3. Soil moisture.

D. Discuss the interpretation of monitoring results and facility operation:

1. Preapplication treatment system.

2. Spray fields.

3. Groundwater.

4. Soils.

7.1.5 Records and Reports

A. Discuss maintenance records:

1. Preventive.

2. Corrective.

B. Monitoring reports and/or records should include:

1. Preapplication treatment system and storage pond(s).

    a. Influent flow
    b. Influent and effluent wastewater characteristics

2. Irrigation System.

    a. Wastewater volume applied to spray fields
    b. Spray field scheduling
    c. Loading rates

3. Groundwater Depth.

4. Drainage system discharge parameters (if applicable).

5. Surface water parameters (if applicable).

6. Soils data.

7. Rainfall and climatic data.

7.2 THORNTHWAITE POTENTIAL EVAPOTRANSPIRATION

The Thornthwaite Potential Evapotranspiration (P.E.T.) is defined as "the amount of water which will be lost from the surface completely covered with vegetation if there is sufficient water in the soil at all times for use of the vegetation." The Thornthwaite method is an empirical equation developed from correlations of mean monthly air temperature with evapotranspiration from water balance studies in valleys of the east-central United States where soil moisture conditions do not limit evapotranspiration (The Irrigation Association, 1983, pp 112 to 114). The Thornthwaite method is applicable to slow rate land treatment systems in the southeast United States including Georgia. It is not applicable to arid and semi-arid regions west of the Mississippi River.

The Thornthwaite equation is outlined below. Note that the results are expressed in centimeters (cm) for a 30 day month. The P.E.T. results must be modified by the actual number of days in each month. Finally, for water balance calculations as described in Section 3.7, a 30 year record of historical climatic data (referred to as the climatological normal) is required to determine monthly temperature normals used in the Thornthwaite equation.

$$\text{P.E.T.} = 1.6 \times Ld \times [(10 \times T)/I]^{A} \qquad \text{eq. 7.2.1}$$

Where,

P.E.T.	=	30 day Thornthwaite Potential Evapotranspiration (cm)
Ld	=	Daylight hours in units of 12 hours (reference Table 7.2-1)
T	=	Mean (normal) monthly air temperature in degrees Celsius
I	=	Annual heat index obtained by summing the 12 monthly heat indexes, i where: $i = (T/5)^{1.514}$
A	=	Power term derived from annual heat index, I where: $A = 0.000000675(I)^3 - 0.0000771(I)^2 + 0.01792(I) + 0.49239$

Table 7.2-1
MONTHLY AVERAGE DAYLIGHT HOURS AS
A FUNCTION OF LATITUDE

	Daylight Hours (x 12 hours)[a]	
Latitude	30 degrees	35 degrees
January	0.90	0.87
February	0.87	0.85
March	1.03	1.03
April	1.08	1.09
May	1.18	1.21
June	1.17	1.21
July	1.20	1.23
August	1.14	1.16
September	1.03	1.03
October	0.98	0.97
November	0.89	0.86
December	0.88	0.85

[a] Values for sites between 30 and 35 degrees latitude should be interpolated.

7.3 DELTA P VALUES FOR GEORGIA CLIMATIC DIVISIONS

Table 7.3-1
DELTA P VALUES FOR GEORGIA CLIMATIC DIVISIONS
(Reference Figure 7.3-1)

Georgia Climatic Division	Delta P[a] (inches)
Northwest	2.0
North Central	2.5
Northeast	3.0
West Central	2.5
Central	2.0
East Central	2.0
Southwest	2.5
South Central	3.0
Southeast	2.5

[a] 20 year variation from 5-year return monthly precipitation. Derived from National Oceanic and Atmospheric Administration historical rainfall data for Georgia.

Figure 7.3-1
GEORGIA CLIMATIC DIVISIONS

7.4 EXAMPLE CALCULATIONS

7.4.1 Introduction and Assumptions

Design of slow rate land treatment systems is a process of balancing site limitations against construction and operating costs. The following example calculations are for a hypothetical one (1) MGD facility in the central Piedmont area of Georgia. They illustrate the basic computations required and the relationship between variables.

The following assumptions were made. They must not be used for real world systems without verification.

a. The average design flow is one (1) MGD with a daily peak factor of 2 and a weekly peak factor of 1.25.

b. The land treatment site is moderately well drained with seasonal high groundwater more than 5 feet below the surface. The most limiting layer in the soil profile occurs at a depth of 2 to 4 feet. Testing for saturated vertical hydraulic conductivity indicates an average permeability for this layer of 0.00015 cm/s corresponding to 0.213 inches/hour.

c. The annual average precipitation is 49 inches. Evapotranspiration occurs at the potential evapotranspiration as computed by the Thornthwaite equation.

d. Nitrogen concentrations in effluent from the preapplication treatment system are as follows:

Total Nitrogen as N	20 mg/L
Ammonia Nitrogen as N	15 mg/L

e. Nitrogen is applied to the site through rainfall and fixation at a rate of 5 lbs/acre-year.

f. Maximum loss to ammonia volatilization is 5 percent of the total ammonia applied. Maximum loss to denitrification for pine forest is 25 percent of the total nitrogen applied. Maximum loss to denitrification for Coastal Bermuda grass is 15 percent of the total nitrogen applied.

g. Net uptake and removal of nitrogen in pine forest with understory growth is 75 lbs/acre-year. Nitrogen uptake and removal for Coastal Bermuda grass is 400 lbs/acre-year.

h. Delta P from Table 7.3-1 is assumed to be 2.5 inches.

7.4.2 Design Percolation

As stated in Section 7.4.1, the average permeability of the most limiting soil layer is 0.213 inches/hour. As this limiting layer occurs at a depth less than 5 feet, 10 percent of this value will be used for design (reference Section 3.6.2). The design percolation rate becomes:

0.10 x (0.213 in/hr) x (24 hr/day) = 0.51 in/day

7.4.3 Water Balance

Water balance calculations for the hypothetical one MGD wastewater irrigation system are presented in Table 7.4-1. This table makes use of eq. 3.7.2 to determine maximum allowable monthly hydraulic wastewater loadings.

Thornthwaite potential evapotranspiration and 5-year return monthly precipitation values for Atlanta are used in Table 7.4-1. The table indicates that for the assumed site conditions, the most critical water balance month is March with a maximum allowable wastewater loading of 8.8 inches, corresponding to 2.0 inches/week. Therefore, a design wastewater loading greater than 2.0 inches/week will require water balance storage. Conversely, no water balance storage will be required for a design wastewater loading less than 2.0 inches/week (reference Section 3.9.3).

7.4.4 Nitrogen Balance

The nitrogen balance is used to evaluate the range of wastewater loadings possible under different cover crop and management schemes. Tables 7.4-2 and 7.4-3 present nitrogen balances for cover crop alternatives of pine forest and Coastal Bermuda grass.

To meet a percolate total nitrogen limit of 10 mg/l, Table 7.4-2 indicates a pine forest cover crop will require a design wastewater loading of 2.0 inches/week or less. Table 7.4-3 indicates Coastal Bermuda grass will allow a design wastewater loading up to the maximum of 2.5 inches/week. The final cover crop selected is an economic decision balancing wetted area and storage requirements against operating cost.

Table 7.4-1
WATER BALANCE CALCULATIONS

Month	Evap[a]	Perc[b]	Precip[c]		D(allowed)
	(in)	(in)	(in)	(in/month)	(in/week)
(1)	(2)	(3)	(4)	(5)[d]	(6)[e]
October	2.5	15.8[f]	4.2	11.1[g]	2.5[h]
November	1.0	15.3[i]	5.9	10.4[j]	2.4[k]
December	0.5	15.8	6.0	10.3	2.3
January	0.4	15.8	6.5	9.7	2.2
February	0.5	14.3	6.4	8.4	2.1

March	1.3	15.8	8.3	8.8	2.0[l]
April	2.5	15.3	6.3	10.7	2.5
May	4.3	15.8	5.8	11.1	2.5
June	5.6	15.3	5.0	10.7	2.5
July	6.4	15.8	6.8	11.1	2.5
August	5.9	15.8	5.3	11.1	2.5
September	4.2	15.3	4.7	10.7	2.5
Total	35.1	186.1		124.1	

[a] Thornthwaite average monthly evapotranspiration.
[b] Based on the (number of days per month) x (a saturated vertical hydraulic conductivity of 0.00015 cm/s or 0.213 in/hr) x a (design safety factor of 10 percent) x 24 hr/day.
[c] Five-year return, monthly precipitation.
[d] The maximum allowable hydraulic wastewater loading is 0.36 in/day x the number of days in the month. Column 5 = Column (2 + 3 - 4).
[e] The maximum allowable hydraulic wastewater loading is 2.5 in/wk.
[f] 31 days x 0.213 in/hr x 24 hr/day x 0.10 safety factor = 15.8 in.
[g] 2.5 + 15.8 - 4.2 = 14.1 in/month. Since 14.1 exceeds the maximum allowable hydraulic wastewater loading of 11.1, 11.1 in/month should be used.
[h] 14.1 in/month ÷ 4.42 days per month = 3.21 in/wk. Since 3.21 exceeds the maximum allowable hydraulic wastewater loading, 2.5 in/wk should be used.
[i] 30 days x 0.213 in/hr x 24 hr/day x 0.10 safety factor = 15.3 in.
[j] 1.0 + 15.3 - 5.9 = 10.4 in./month.
[k] 10.4 in/month ÷ 4.28 days per month = 2.4 in/wk
[l] 2.0 in/wk is the lowest value in column 6. In this example the month of March is the most critical water balance month.

Table 7.4-2
NITROGEN BALANCE, PINE FOREST

1.	Average Daily Flow ADF (mgd)	1.0[a]	1.0	1.0	1.0
2.	Average Design Wastewater Loading (in/week)	1.25[b]	1.50	1.75	2.00
3.	ADF Wetted Area (in/week)	206[c]	172	147	129
4.	Nitrogen Input from Wastewater (lbs/acre-year)	296[d]	354	414	472
5.	Nitrogen Input from Rainfall and Fixation (lbs/acre-year)	5[e]	5	5	5
6.	Total Nitrogen Input (lbs/acre-year)	301[f]	359	419	477
7.	Ammonia Volatilization @ 5% of Ammonia Applied (lbs/acre-year)	11[g]	13	16	18
8.	Denitrification, @ 25% of Total Nitrogen applied (lbs/acre-year)	75[h]	90	105	119

9.	Net Plant Uptake and Storage (lbs/acre-year)	75[i]	75	75	75
10.	Nitrogen Leached by Percolate (lbs/acre-year)	140[j]	181	223	265
11.	Precipitation (in/year)	49[k]	49	49	49
12.	Wastewater Applied (in/year)	65[l]	78	91	104
13.	Potential Evapotranspiration (in/year)	35[m]	35	35	35
14.	Percolate (in/year)	79[n]	92	105	118
15.	Estimated Percolate Total Nitrogen (mg/l)	7.8[o]	8.7	9.4	9.9

[a] Given value, 1.0 mgd

[b] Selected design loading, 1.25 in/wk

[c] $\frac{\text{7 days x 1,000,000 gal/day x 12 in/ft}}{\text{7.48 gal/cf x 43,560 cf/acre x 1.25 in/wk}}$

[d] Given Total Nitrogen value = 20 mg/l

$\frac{\text{20 mg/l 8.34 lb/gal x 1.0 mgd x 365 day/year}}{\text{Line 3 value}}$

[e] Constant from atmosphere, 5 lbs/acre-year

[f] Line 4 value + Line 5 value

[g] Given Ammonia Nitrogen value = 15 mg/l

$\frac{\text{15 mg/l x 1.0 mgd x 8.34 lbs/gal x 365 day/year x 0.05}}{\text{Line 3 value}}$

[h] Line 6 value x 0.25

[i] Constant

[j] Line 6 value - Line 7 value - Line 8 value - Line 9 value

[k] Given

[l] Line 2 value x 52 wks/year

[m] Given

[n] Line 11 value + Line 12 value -Line 13 value

[o] $\frac{\text{Line 10 value x 4.41}}{\text{Line 14 value}}$

Table 7.4-3
NITROGEN BALANCE, COASTAL BERMUDA GRASS

Average Daily Flow ADF (mgd)	1.0	1.0	1.0	1.0
Average Design Wastewater Loading (in/week)	1.75	2.00	2.25	2.5
ADF Wetted Area (in/week)	147	129	114	103
Nitrogen Input from Wastewater (lbs/acre-year)	414	472	534	591
Nitrogen Input from Rainfall and Fixation (lbs/acre-year)	5	5	5	5
Total Nitrogen Input (lbs/acre-year)	419	477	539	596
Ammonia Volatilization @ 25% of Ammonia Applied (lbs/acre-year)	16	18	20	22
Denitrification, @ 25% of Total Nitrogen applied (lbs/acre-year)	63	72	81	89
Net Plant Uptake and Storage (lbs/acre-year)	400	400	400	400
Nitrogen Leached by Percolate (lbs/acre-year)	0	0	38	85
Precipitation (in/year)	49	49	49	49
Wastewater Applied (in/year)	91	104	117	130
Potential Evapotranspiration (in/year)	35	35	35	35
Percolate (in/year)	105	118	131	144
Estimated Percolate Total Nitrogen (mg/l)	0.0	0.0	1.3	2.6

7.4.5 Operating Scheme

The operating scheme for the hypothetical one MGD facility is as follows:

a. The average initial design wastewater loading will be 2.5 inches/week. The actual loading rate will be somewhat less than 2.5 inches/week during normal operation because the additional acreage needed for treating the operational storage, water balance storage and wet weather/emergency storage will be used to treat the normal daily flows. This will be done in order to maintain the cover crop regardless of whether there is any water in storage.

b. The maximum allowable instantaneous application rate is 0.213 in/hr (ref. 7.4.1b). For this example an instantaneous application rate of 0.20 in/hr will be used.

c. The cover crop will be Coastal Bermuda grass. The grass will be harvested and sold.

d. Normal operation will be five (5) days per week. The flow from the other two days will be stored. Since the system will normally be operated five days per week, the wastewater volume applied each day is:

   [(7 days/week)/(5 days/week)] x 1 MGD = 1.4 MGD

7.4.6 Storage Volume Requirements

As discussed in Section 3.9, the required storage volume consists of three (3) <u>separate</u> storage components.

a. Operational Storage

   The operating scheme selected for design calls for irrigation five days per week with storage of two days' flow. The required operational storage is:

   (7 days - 5 days) x 1 MGD = 2 Mgal

   For this example it is assumed that harvesting of the grass will not occur during the wet weather months. Therefore, no additional storage will be needed for fields out of service due to harvesting since the wet weather storage volume will be available.

b. Wet Weather and Emergency Storage

Minimum requirements for wet weather and emergency storage are discussed in Section 3.9.2. These are the greater of 12 days flow or the results of eq. 3.9.2 .

For the hypothetical facility, Delta P from Table 7.3-1 is assumed to be 2.5 inches. The maximum allowable hydraulic wastewater loading in the most critical water balance month (March) from Table 7.4-1 is 8.8 inches/month. By eq. 3.9.2:

$$\frac{2.5 \text{ in/wk} \times 365 \text{ days/yr}}{12 \text{ months/yr} \times 8.8 \text{ in/month}} = 8.6 \text{ days}$$

8.6 days is less than the 12 day minimum storage requirement. Therefore, the required wet weather and emergency storage is:

12 days x 1 MGD = 12 Mgal

c. Water Balance Storage

As discussed in section 3.9.3, the water balance storage is a function of hydraulic loading rate which is a function of the total wetted field area. Therefore, before the water balance storage can be determined the wetted field area must be defined.

7.4.7 Wetted Field Area Determination

The area required for the spray site is the total of four separate components, as discussed in Section 3.10.

A(wetted) = A(ADF) + A(OP) + A(WW/E) + A(WBS)

Substituting the appropriate loading rates and the appropriate volumes into equations 3.10.1 and 3.10.3 results in the following wetted area requirements:

$$A(ADF) = \frac{7 \text{ days/wk operation} \times 1{,}000{,}000 \text{ gpd} \times 12 \text{ in/ft}}{7.48 \text{ gal/cf} \times 43{,}560 \text{ sf/acre} \times 2.5^{a} \text{ in/wk}}$$

[a] 2.5 in/wk is the maximum allowable wastewater loading

A(ADF) = 103 acres

$$A(WW/E) = \frac{12 \text{ days storage} \times 1{,}000{,}000 \text{ gpd} \times 7 \text{ days/wk} \times 12 \text{ in/ft}}{7.48 \text{ gal/cf} \times 43{,}560 \text{ sf/acre} \times 90 \text{ days} \times 2.0^{b} \text{ in/wk}}$$

[b] 2.0 in/wk is the most critical water balance month wastewater loading

A(WW/E) = 17 acres

Since the only operational storage is associated with spraying less than 7 days per week:

A(OP) = 0.0 acres

With these areas determined the next step is to define the necessary water balance storage and the wetted area associated with that storage.

The wastewater loading rate (WLR) is:

$$\text{WLR} = \frac{7 \text{ days/wk} \times 1{,}000{,}000 \text{ gpd} \times 12 \text{ in/ft}}{7.48 \text{ gal/cf} \times 43{,}560 \text{ sf/acre} \times 120^{c} \text{ acres}}$$

[c] A(ADF) 103 acres + A(WW/E) 17.1 acres = 120.1 acres

WLR = 2.15 in/wk

Table 7.4-4 combines eq. 3.7.2 and 3.9.3 to determine the required water balance storage (WBS) for the loading rate of 2.15 in/wk. The table indicates a total water balance storage of 0.9 inches over the wetted area of 120 acres. Storage for the most critical month (March) is:

$$\frac{0.9 \text{ in.} \times 120 \text{ acres} \times 7.48 \text{ gal/cf} \times 43{,}560 \text{ sf/acre}}{12 \text{ inches}} = 2.93 \times 10^{6} \text{ gal}$$

Substituting the appropriate values into eq. 3.10.4:

$$\text{A(WBS)} = \frac{2{,}930{,}000 \text{ gal} \times 7 \text{ days/wk} \times 12 \text{ in/ft}}{90 \text{ days} \times 7.48 \text{ gal/cf} \times 43{,}560 \text{ sf/acre} \times 2.15 \text{ in/wk}}$$

A(WBS) = 4.0 acres

Table 7.4-4
WATER BALANCE STORAGE

Month	D(potential)[a]	D(allowed)[b]	WBS[c]	Sum WBS[d]
October	9.5[e]	11.1	0.0	0.0
November	9.2	10.4	0.0	0.0
December	9.5	10.3	0.0	0.0
January	9.5	9.7	0.0	0.0[f]
February	8.6	8.4	0.2	0.2[g]
March	9.5	8.8	0.7	0.9[h]
April	9.2	10.7	0.0	0.0[i]
May	9.5	11.1	0.0	0.0
June	9.2	10.7	0.0	0.0
July	9.5	11.1	0.0	0.0
August	9.5	11.1	0.0	0.0
September	9.2	10.7	0.0	0.0

a Based on the number of days per month and the actual wastewater loading of 2.15 in/week, assumes all influent wastewater is applied to spray fields.

b Values from Table 7.4-1.

c WBS = Water balance storage, reference eq. 3.7.4.

d A positive WBS value indicates that no WBS is required for that month. A negative WBS value indicates that WBS is required for that month.

e $\frac{\text{31 days/month}}{\text{7 days/week}}$ = 4.42 weeks/month

4.42 wk/month x 2.15 in/wk = 9.5 inches

f 9.7 in. - 9.5 in. = 0.2 in., the value is positive which indicates that no WBS is required for this month.

g 8.4 in. - 8.6 in. = -0.2 in., the value is negative which indicates that WBS is required for this month.

h 8.8 in. - 9.5 in. = -0.7 in., the value is negative which indicates that WBS is required for this month. The accumulated WBS is -0.2 in. - 0.7 in. = -0.9 in.

i 10.7 in. - 9.2 in. = 1.5 in., the value is positive but must be added to the previous WBS value. -0.9 in. + 1.5 in. = 0.6 in. The value is positive which indicates that no WBS is required.

The total area necessary for this land treatment system is:

A(ADF)	103 acres
A(OS)	0
A(WW/E)	17
A(WBS)	4
A(TOTAL)	124 acres

Spraying 1.4 Mgal each day for five days per week, the wetted field area will be divided into 24.8 acre sections. For normal flows each field will be loaded at a rate of:

$$\frac{1.4 \times 10^6 \text{ gal/day} \times (12 \text{ in/ft})}{7.48 \text{ gal/cf} \times 43{,}560 \text{ sf/acre} \times 24.8 \text{ acres}} = 2.1 \text{ in/wk}$$

The average wastewater irrigation period will be:

(2.1 in/week)/[(1 day/week) x (0.20 in/hr)] = 10.5 hr/day

The maximum wastewater irrigation period will be:

(2.50 in/week)/[(1 day/week) x (0.20 in/hr)] = 12.5 hr/day